SOIL CONSERVATION

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Here and there among the Regions

THIS issue is made up entirely of material from the field. Each of the 11 regions is represented.

FEW students of soil conservation may travel extensively among projects, camps, and experiment stations in search of usable ideas or new points of view. Most of us must rely on SOIL CONSERVATION, and other mediums, to do our traveling for us, by proxy.

THIS month the magazine makes a quick round of the regions, from coast to coast, bringing back a varied collection of notes, pictures, maps. Each contribution is included because of some unique quality or because it adds a significant footnote to the growing encyclopedia on soil-erosion problems and their solution.

REGIONS - 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 - 11

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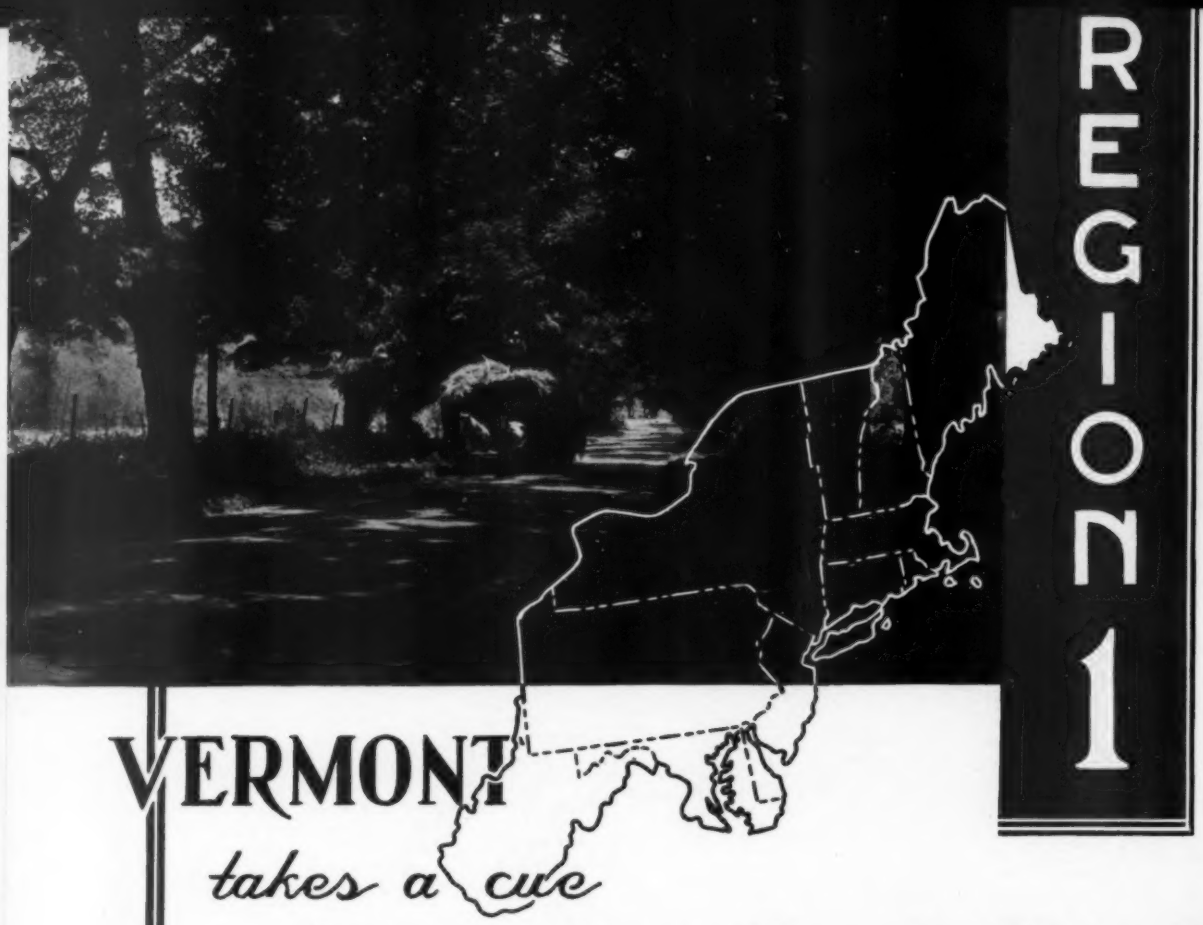


VERMONT takes a cue from the Dust Bowl

By C. B. Maits, Jr.[1]

ON SANDY soils left by the great ice sheet more than 25,000 years ago, the removal of trees, combined with overgrazing of pastures, has resulted in the formation of small sand blows, ranging from a few feet to almost 20 acres in size. These blows have caused concern for some time among farmers on the Vermont plateaus and steep slopes above the Winooski River.

There are no dust storms in Vermont resulting from creeping sands. Nevertheless, 2,000 miles away from the Great Plains, New England farmers do have a "dust bowl" problem. The blowing sandy wastes are encroaching on their pasturelands—pasturelands that support herds of cattle which are the livelihood of many farmers in one of the country's oldest agricultural communities.

Since deforestation and overgrazing have been the primary and secondary causes respectively of the sand blows, reforestation and controlled grazing are the long-run methods advocated by the Soil Conservation Service to help farmers overcome their wind-erosion problem. For temporary control, many farmers in the Winooski Valley area are resorting to the use of "whisker" terraces and strongly built fences of tree limbs and brush. The "whisker" terraces are merely bundles of brush and limbs staked around the contour of the blows to check further drifting. They are effective on small areas. On larger blows, erosion-control technicians have taken their cue from soil-conservation practices which check water damage in other parts of the Northeastern States. They are using the tree-limb fences to break the sand blows into compartments to minimize the chances of dune formation and smothering of adjacent grassed areas. In other words, just as diversion terraces break up the velocity and volume of water by reducing the size of

[1] Section of Information, Soil Conservation Service, Williamsport, Pa.

"Whisker" terraces are temporarily effective on small areas.

drainage areas, so these fences break up the shifting of sands by cutting down the "blowing" area.

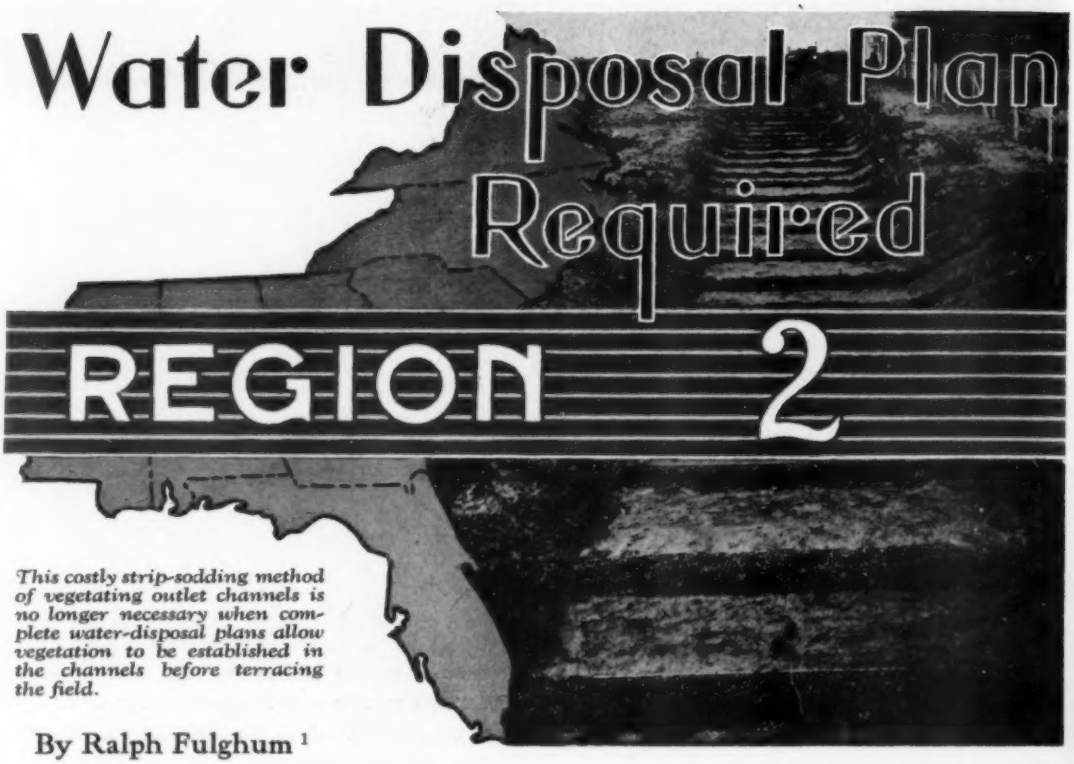
Thousands of pine seedlings are being planted in these tree-fence compartments in the large areas, and between the "whisker" terraces on the smaller areas. Their roots can find a way to productive soil beneath the sandy wastes, and, in years to come, will effect a permanent cure for many a Vermont farmer's midget desert. Fencing is necessary also on both the large and small areas to prevent grazing animals from browsing the seedlings or destroying the structures built for temporary control.

On many of the blows farmers are making effective use of what would otherwise be wasteland by including wildlife plantings in the reforestation process. In the not so distant future, farmer-owners on the hills of the Winooski demonstration area will derive direct benefit from these plantings. The blows will be changed from sterile, creeping wastes to wooded thickets where fur bearers or game birds can find homes and provide a return worth many times the effort expended in halting the miniature but growing menace of wind erosion.

A larger sand blow broken into compartments by tree-branch fences. Pine seedlings, planted at close intervals, will give permanent protection within a few years.

Water Disposal Plan Required

REGION 2



This costly strip-sodding method of vegetating outlet channels is no longer necessary when complete water-disposal plans allow vegetation to be established in the channels before terracing the field.

By Ralph Fulghum [1]

A WATER disposal plan for the entire farm is now required as a part of all new cooperative agreements and all agreements being amended in camp and project areas in Region 2. The ruling became effective November 1 of this year. Such a system was adopted in South Carolina a year ago, and water-disposal plans have been made a part of almost 2,000 cooperative agreements in the State. In its initial stage the system was so successful as to merit its extension to the entire region.

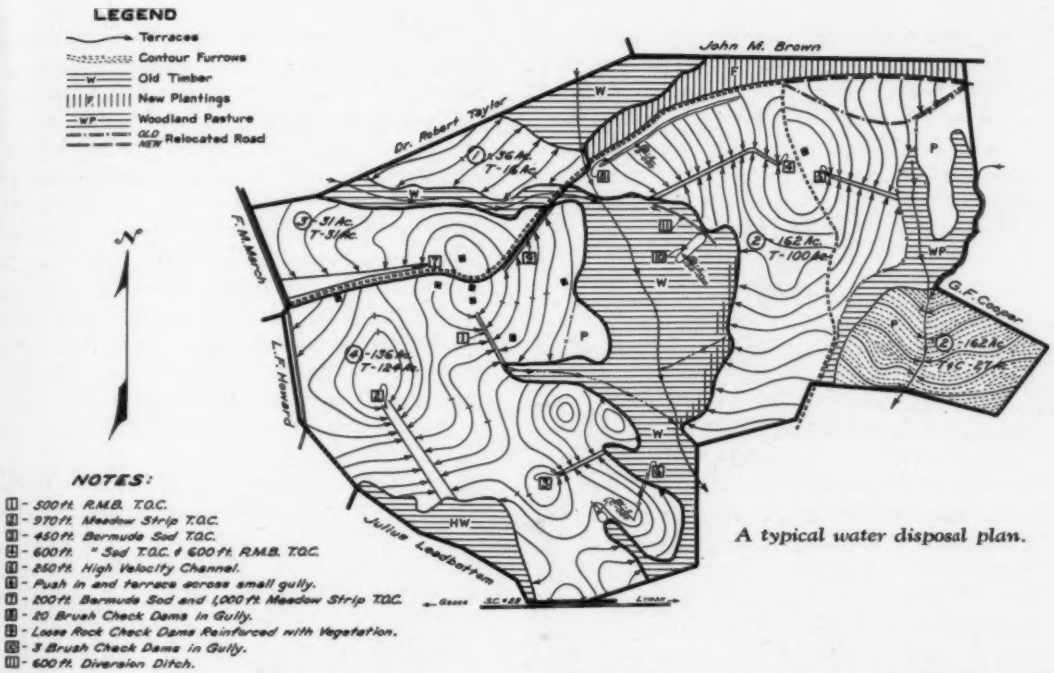
These advanced plans have encouraged the use of vegetation in waterways, have greatly reduced the cost of the practice, and have given the farmer a better understanding of what he needs on his farm. It appears also to be one of the best methods by which the engineer can render technical assistance to large numbers of farmers in organized districts.

Appearing somewhat like a weather map but with the arrows representing terraces instead of pressure areas, the plan for each farm shows where the necessary terraces are to drain, where terrace outlet channels and meadow strips will be needed, wooded areas that should be allowed to thicken before water is turned on to them, gullies to be vegetated before taking water from terraces, necessary relocation of roads, required stream-bank erosion control, pastures to be contoured, and other measures important in a plan devised to provide eventually complete control of all run-off water on the farm.

BY GIVING careful consideration to outlet locations and the establishment of vegetation before permitting any flow of water, the South Carolina farmers and engineers are able to take advantage of natural vegetative development. This allows also the location of strategic points for disposal of water and their reinforcement with vegetation, thus securing greater distribution of outlet water and less concentration in channels.

Engineers and farmers in this region have found that by sprigging the channels a satisfactory vegetative stand can be established at about one-fourth the cost of strip-sodding—a procedure necessary when the channels must take concentrated water immediately. The actual cost of strip-sodding 6 outlet channels of about average size in one of the camp areas was 50 cents per linear foot of channel. The average cost of

[1] In Charge, Information, Soil Conservation Service, Spartanburg, S. C.


LEGEND
Terraces
Contour Furrows
Old Timber
New Plantings
Woodland Pasture
Relocated Road
John M. Brown
Dr. Robert Taylor
F. M. March
L. F. Howard
Julius Leadbetter
G. F. Cooper
NOTES:
- 500 ft. R.M.B. T.O.C.
- 970 ft. Meadow Strip T.O.C.
- 450 ft. Bermuda Sod T.O.C.
- 600 ft. " Sod T.O.C. & 600 ft. R.M.B. T.O.C.
- 250 ft. High Velocity Channel.
- Push in and terrace across small gully.
- 200 ft. Bermuda Sod and 1,000 ft. Meadow Strip T.O.C.
- 20 Brush Check Dams in Gully.
- Loose Rock Check Dams Reinforced with Vegetation.
- 3 Brush Check Dams in Gully.
- 600 ft. Diversion Ditch.

A typical water disposal plan.

preparing and sprigging 5 similar channels in the same area recently and considerably in advance of terracing was 14 cents per linear foot.

The practice of allowing vegetation to become established in the channels before concentrated water is turned on to it should lessen the maintenance cost necessary to keep the channel functioning properly. This is emphasized by experience in South Carolina with sod-stripped channels which were used to carry concentrated water before the roots had become firmly established. In the event of heavy rains the sod was washed out. Eliminating maintenance work will make the channels more effective and further reduce costs.

WHEN the farmer has in hand a copy of the complete water-disposal plan and knows that it is a part of his agreement he has a better understanding of the complete program needed to check erosion on his farm. It also shows him a starting point as well as a definite goal toward which he can work. Usually a farmer does not terrace more than a fourth to a third of his land in a season; but with a complete plan in mind he can start vegetation on all outlets, and build the terraces as time permits during the next several years. With completion of the system in sight, the farmer has every incentive to speed up terracing.

This meadow strip is making hay, as well as establishing a dense sod of vegetation to take care of water that later may be terraced into it.

The water-disposal plan permits the engineer to make fewer trips to the farm while at the same time it allows him to render a more complete technical service to the farmer on control of run-off water. The plan affords the supervising engineer the opportunity to maintain better control of the recommended practices, and gives him the chance to discuss with

his assistants all possible methods of treatment before the agreement is signed.

Before adoption of the plan, the South Carolina engineers were pushed to keep a jump ahead of the tractors and terracing machines that were being operated on camp and project areas and by cooperative soil-conservation associations. Now they have completed advance water-disposal plans on all cooperating farms in camp areas, and in all project areas except the two oldest in the State where work was almost completed before the plan was inaugurated.

In the camp areas alone there are now complete water-disposal plans covering 110,000 acres of land under agreement and still to be terraced—this being twice the amount of land terraced in the area during the last 2 years. In the plans for the farms, 1,064 terrace outlet channels and 192 meadow strips are provided for and these are being established as fast as the cooperating farmers and the C. C. C. boys can do the work. In the last 7 months 50 of the outlet channels have been prepared and sprigged to Bermuda grass and other vegetation.

Before the system of making advanced water-disposal plans was initiated, the amount of work available for C. C. C. camp crews was largely determined by the number of tractors operating in the area. Now, however, the plans provide an almost unlimited amount of work that can be done on outlets, and this regardless of the number of tractors or whether or not it is too wet for them to operate. The work to be done in establishing the outlet channels in advance of terracing is also very largely of a type which the farmer himself can do with ordinary labor and farm equipment.

When the erosion-control program was first started in this region, tractor crews had to be put to work and demonstration terraces had to be built quickly, often without consideration of proper outlets. In those days masonry structures played a big part in the program. Vegetation was slow, and speed was the watchword.

As more and more experience was gained the emphasis shifted to more practical vegetative protection, and it was realized that concentrated water from terraces could not safely be turned onto newly planted vegetation. It was with the idea of establishing the vegetation first, and at the same time giving the engineer better control over the water-disposal program, that the South Carolina workers, in August 1936, initiated the complete water-disposal plan as a requirement supplementing all cooperative agreements in the State. Although the establishing of outlet channels and meadow strips prior to the building of terraces has been practiced in a number of locations throughout Region 2 as a whole, the complete water-disposal plans were not developed extensively in any area other than South Carolina.

According to John Downing, the associate agricultural engineer directing the work in South Carolina, one engineer was able to make the usual water-disposal plan for a 100-acre farm in about a half day. A good draftsman can make the tracings to be blueprinted in 2 or 3 hours, and the total cost other than the engineer's time for making the average plan is between $2 and $3. This cost has been far more than offset by the decreased cost of vegetating channels in advance and the other advantages of the plan.

The engineer when making the water-disposal plan determines by the general lay of the land where outlet channels will be needed and what type should be established. The channel is then prepared, fertilized, and sprigged with Bermuda grass simply by scattering sprigs of grass over the area and turning them under, or is planted to other suitable vegetation. Bermuda

grass is established only in the center of the channels, some other vegetation such as lespedeza sericea being used on the edges to prevent the Bermuda from spreading into the field. Channels prepared in this manner normally are ready to take water from terraces in about 6 months. Meadow strips may normally take water with the second-year growth.

Many of the water-disposal plans call for trees and other vegetation to thicken portions of wooded areas. In about a year's time much can be accomplished toward thickening such areas so that they can safely take water from terraces and outlets. The plans also provide for gully control in the form of tree and other vegetative plantings, as well as diversion of water

(*Continued on p. 167*)

Twelve-foot hybrid corn on a 20-percent slope. The field is being farmed in strips.

Strip Cropping
In Hill Country of OHIO

By J. S. Cutler [1]

FARMERS in narrow White Eyes Valley are making things a lot easier for Carl Schwab, who grades the roads through that part of Coshocton County, Ohio. Strip farming, something that would have shocked their fathers—and still shocks some of them—has penetrated this little gorge which feeds the muddy Tuscarawas.

Clark Bahmer, who had never heard of the Soil Conservation Service, started it. Zeno Hawk, 5 miles down the road, laid out his own strips when he bought his father's farm. Neighbors read about it, saw it, tried it, and liked it. Now, along the winding macadam road bordering White Eyes Creek travelers view a panorama of winding strips and contour bands. And the soil doesn't wash down on the highways so much. The operator of a road grader will tell you that.

WHITE Eyes Valley is small, yet the spread of strip cropping into the hill country is typical of the growth of this soil-saving practice in rolling Ohio.

County agents have their hands full answering questions and requests. Farmers who have adopted it say they "would not go back to the old-style farming for two thousand dollars." Ohio farm journals and newspapers are full of it. Tours of soil conservation projects send farmers back home to "try it." At least one farmer in every township in Jefferson County adopted strip cropping in 1937. Out of 1,791 farms in Hocking County, 3 were laid out in strips in the same year—the beginning of the practice for that area. "You try it, and I'll watch it," as one farmer told his neighbor, has become "I believe I'll try it."

TO FOLLOW the spread of strip cropping in Ohio a knowledge of the State's topography is necessary. The surface features range from level plains with not more than 10 feet variation in elevation for several miles, to rough hills with steep slopes rising almost precipitously to a height of 300 to 500 feet above the valleys. The southern and eastern portions, known as the hill country, consist of a succession of hills and sharp, winding ridges, separated by deep, narrow valleys. It is the hill country that has grasped strip cropping as the only means of tilling land where slopes commonly run up to 30 percent.

The origin of strip cropping in Ohio is open to question, since the practice probably started spontaneously at several different places, but Belmont County is regarded as the cradle of the strip-farming system. A recent preliminary study of 25 farms in the eastern portion of the county showed that 10 farmers had been practicing strip farming for more than 25 years. Despite the fact that certain progressive farmers have been using this type of hill tillage for a generation, only in recent years has the practice spread to the southern and western parts of Belmont County, this spread being due largely to educational work.

[1] Regional conservator, Soil Conservation Service, Dayton, Ohio.

The shaded counties are those in which strip-cropping is in effect.

Of the 25 farmers included in the study, each had been strip cropping for more than 5 years. Some had learned about the practice from their fathers, others by observing the work on neighboring farms. Still others noticed that meadow strips would catch and hold the deposit from eroding fields above.

Some strip cropping began accidentally, for convenience rather than to control soil erosion. Such is the case of Herbert F. Neff, of Belmont County. Neff admits that he adopted strip cropping somewhat by accident, when he moved his fences to make his fields of suitable size to work with a tractor. The new arrangement was such an improvement in preventing soil erosion that it has been continued. The Belmont County farmer says that he not only saves topsoil, but derives more benefit from rainfall than he did formerly.

These farmers started and studied strip cropping by the trial and error method. Strips were laid out by the eye, and changed from time to time to reduce the amount of erosion. Principal changes made were the narrowing of strips, putting the strips more nearly on the contour, and lengthening the strips to facilitate cultivation of crops.

But strip cropping stayed close to its cradle. For years it did not spread, even to adjoining counties.

(*Continued on p. 168*)

The owner of this Hocking County farm, upon touring the Salt Creek project, was impressed with strip cropping and became the first in his county to adopt the practice. Note the excellent appearance of buildings and fields.

Meadow Outlet Strips

Meadow strip terrace outlet channel planted to oats and Sudan, stripped to Bermuda grass. This scene on a Garland, Tex., farm shows a complete program embracing strip crops, terraces, vegetated outlets, meadow strip outlet, and contour cultivation.

By Harold G. Anthony [1]

SINCE that eventful but unrecorded day many long years ago when the first terrace was constructed for the purpose of controlling eroding run-off, the problem of water discharge from terrace ends has been of deep concern to agricultural engineers and farmers alike. In the South, as farmers became interested in this single-phase erosion-control measure the problem was accentuated rather than solved, and at an early date it became evident that not only the success of any given terrace system, but the whole idea of terracing for erosion control was dependent upon a successful solution of the terrace outlet enigma. For many years, however, roadside ditches were washed out by red, bald-faced gullies; and sinking fence rows provided mute evidence of the futility of protecting one field with terraces while speeding destruction on adjoining areas where the water was dumped.

CONTRIBUTIONS to the ultimate solution of the problem were provided by decreased and variable grades and level terraces in low rainfall sections. But these were not enough. Simple to elaborate individual outlet and outlet-channel structures of concrete, rock, asphalt, wood, and other materials put in their appearance; and no one could deny their effectiveness nor their importance as contributions to the final solution for safely handling terrace water. Progress was being made, even though from the viewpoint of the landowner and operator these structural outlets and channels were costly and often prohibitive.

And then came the vegetation method of controlling terrace water—a procedure which, in spite of periodic appearances throughout the decades, was never widely adapted until the multiphase erosion-control program of the Soil Conservation Service began planting its roots throughout the Southland.

THIS is not an article of historical or record interest however, for the purpose of tracing developments and progress in solving the problem of handling terrace waters; nor is it claimed that the final solution has been discovered. My purpose is to explain in some detail the use of meadow outlet strips as one method of safely outletting terrace water. Like others, this method is not all-inclusive, and it can be used success-

[1] In Charge, Information, Soil Conservation Service, Fort Worth, Tex.

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fully only under certain given conditions; but it has proved so satisfactory wherever adapted throughout Region 4 that it is offered as one of the best.

In this region, vegetated individual terrace outlets, vegetated outlet channels, and meadow outlet strips have universally supplanted in effectiveness and desirability all other schemes of "engineered" methods for disposal of terrace water. As a matter of course, however, the method which receives first consideration by planning groups is the outletting of terrace water on to unburned properly managed woodland, well-sodded pasture, or established meadows. This, the natural and simplest plan, is used when at all possible and practical.

In project and camp areas in Region 4, as always when establishing outlets, the location of meadow strips is determined well in advance of terrace construction. In this way, the outlet strip may be well established and protected by vegetation before it is ready for actual use.

MEADOW outlet strips are located to afford protection to the maximum number of terraced acres at the minimum cost. To bring about this condition, when terraces approach the maximum desirable length if possible they are brought into the meadow outlet. In some instances a meadow strip can be located along a fence or property line where it will serve two landowners or operators. It is also necessary, when fields are unusually large, to locate meadow strips in the center of the field in order to avoid excessively long terraces.

Wherever practical, meadow outlets are used as a means to terrace outlet protection. This is especially true of Arkansas project and camp areas where the general topography of the land is such as to make the use of outlet strips both practical and economical. The strips have become very popular among cooperators and landowners outside project and camp areas, particularly because of the ease of duplication and the excellent utilization of such areas, when fenced and carefully managed, for hay crops and additional pasturage.

The meadow outlet strips should be located in a natural depression that is large enough to carry the volume of run-off diverted into it by the terrace system. Such depressions must have the lowest possible grade. It is often possible to use a location where there is a small gully or wash, by establishing the meadow on each side of the cut. Stabilization of the small gully can be accomplished by the use of sod bags or other vegetative control means. This stabilization procedure is aided by plowing in, or by any other method whereby the gully banks are sufficiently sloped to allow machinery operations and crossings. It should be pointed out here that full consideration must be given to the suitability of the site selected, and to the effect on cultivation practices in the field, before starting construction.

A minimum width of 100 feet has been adopted as standard in Region 4. This width ensures proper utilization of the meadow outlet strip and adequately allows for any abnormal rainfall that might otherwise overflow on to cultivated land. It must be constantly borne in mind in laying out meadow strips that they must have ample capacity so that water will not tend to overflow on to the cultivated area on either side.

In this region technicians have found that slopes up to 4 percent can be held by meadow grasses commonly used for hay. Bermuda grass will afford the desired protection on slopes from 4 to 6 percent. On such slopes, and on all slopes on the more erodible soil types, it is advisable to place strips of Bermuda grass sod across the meadow strip at vertical intervals of from 0.2 to 0.5 foot. These sod strips act as spreaders. For protection under normal rainfall conditions, they may extend only across the lowest part of the strip channel and it is not necessary that they extend the full width of the strip. It is also recommended that where available, Bermuda grass be used in the portion of the meadow outlet which is covered by the run-off from rains of average intensity.

On the poorer soils where vegetative growth is normally slower, meadow outlet strips can be fertilized with barnyard manure or a complete commercial fertilizer to hasten the establishment of a protective growth.

In order to prevent water cutting back and forming a gully along the edge in the cultivated field, terraces should be constructed to extend at least 12 feet into the strip. Experience with meadow outlet strips in Region 4 has shown that the last 50 to 100 feet of terraces entering the strip should be turned somewhat downhill and the depth of the cut on the upper side gradually reduced. This will bring the bottom of the terrace channel into the strip at a point near the ground level without changing the normal terrace grade.

At present a total of 3,800 acres in Region 4 project and camp areas are being profitably utilized in meadow

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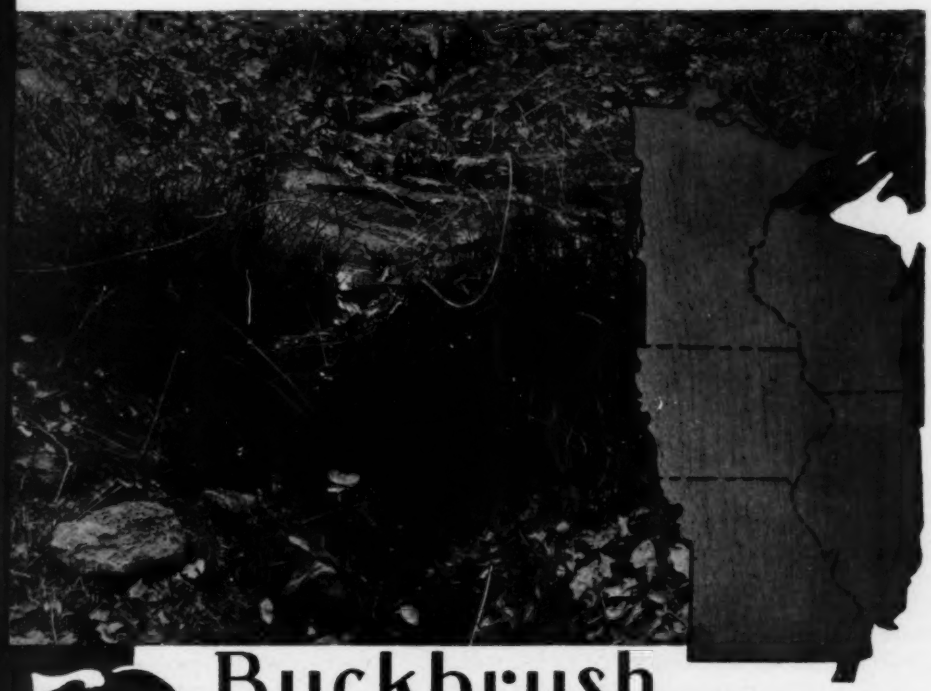
REGION 5



Buckbrush Check Dams

A gully completely stabilized by the diversion of water through pasture terraces, fencing out livestock, planting of trees and grass, and inexpensive brush dams.

By W. W. Russell and L. H. Kahler [1]

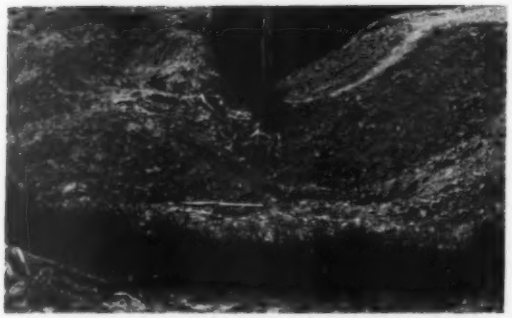
IN THE Dubois Creek erosion-control demonstration area near Washington, Mo., several hundred "living dams" are to be found, and they are effectively healing gullied areas. Here are structures that are mechanical treatments, and yet they are vegetative treatments as well. They require engineering designs, and yet a forester plants them.

In the past, the type of temporary gully-control structure most widely used in the Dubois Creek project was the wire-and-brush check dam. These were rather expensive both in materials and labor, and often the cost of the structure was not justified by the value of the land protected. As a result, structures were not built in many gullied areas which needed temporary stabilization prior to the establishment of vegetative cover.

[1] Junior Foresters, Dubois Creek demonstration project, Soil Conservation Service, Washington, Mo.

WITH these points in mind, members of the woodland management section of the Dubois Creek project last year observed that buckbrush (*Symphoricarpos vulgaris*) grew abundantly on all soil types; that it spread naturally, but could be controlled by cultivation; that it was resistant to the grazing of livestock; that it was hardy, resisting extremes in temperature; that it was an excellent soil binder, often controlling small gullies and occasionally controlling small overfalls; that it could be transplanted easily; and that it was present in sufficient quantities to be transplanted. Why not use buckbrush checks in place of the old wire and brush checks?

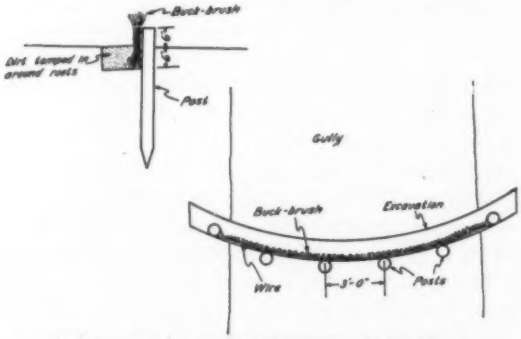
Accordingly the woodland management section on the project developed two types of buckbrush checks: (1) Those with a wire backing, and (2) those without wire. The purpose of the wire is to support the buckbrush at least until its roots develop and it can support itself. Experience with the structures in the Dubois Creek project indicates that buckbrush checks in gullies draining over half an acre should be backed with wire. In smaller drainage areas, the wire is not considered necessary.



Eventually, it is hoped, the living brush will spread up and down the gully, giving complete control.

IN CONSTRUCTING a buckbrush check without wire, a trench 8 inches deep is dug in a modified V-shape across the gully. Buckbrush is grubbed, obtaining a 4-inch or longer root if possible, and immediately transplanted into the trench. Soil is tamped in around the roots. Enough buckbrush is placed in the check to make a screen almost impervious to light.

In constructing a buckbrush check with wire, the same type of trench as that described above is used. Posts are made of any wood the farmer has available and driven along the downstream side of the trench, spaced 3 feet apart. Woven or barbed wire is then stapled to the upstream side of the posts, the height of the wire in the bottom of the gully never being more than 6 inches above the flow line. The height is limited to 6 inches in order to reduce the height of the backfill that will form, thus reducing the possibility



End and top views of buckbrush check dam.

of creating an overfall. Litter will soon seal the check and the backfill will develop naturally.

The roots of buckbrush should not be allowed to dry out, and it is important that the brush be planted as soon as possible after grubbing.

A unique feature of these structures is that they require no aprons. When the backfill has formed, water running over it will percolate down through the buckbrush and experience has shown that only in extreme cases does an overfall occur.

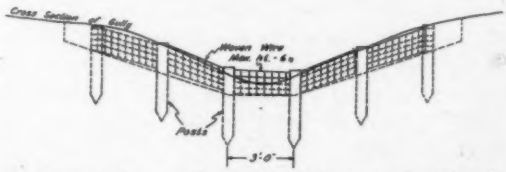
To date, 267 buckbrush checks without wire have been constructed in the Dubois Creek project at an average cost in labor of 3.8 man-hours per check. One hundred and seven buckbrush and wire checks have been built at an average cost of 6.3 man-hours per check. In most cases the only cash outlay for materials was for staples.

The first buckbrush dams were placed in the Dubois Creek project in the early fall of 1936, and buckbrush plantings were continued throughout the winter of 1936–37. A few checks were placed during the spring planting season in 1937.

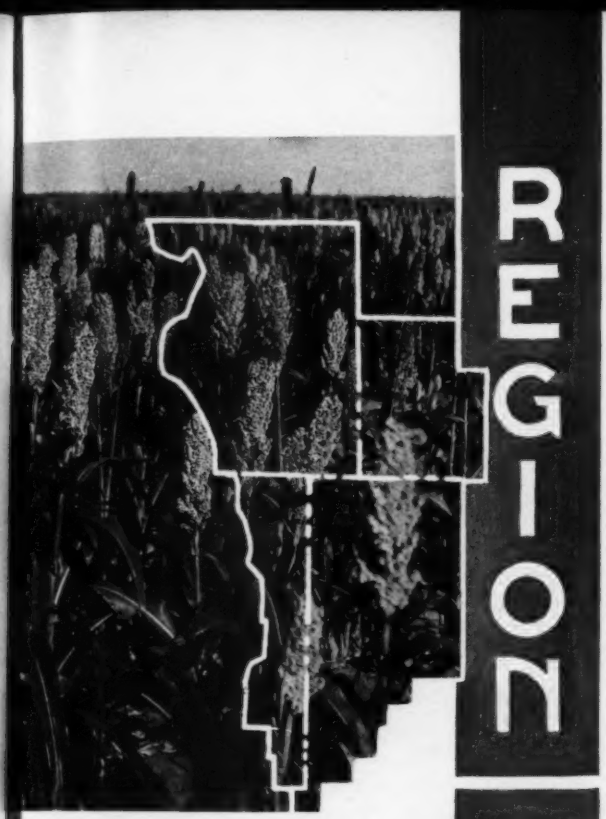
While the period during which the dams have been in use is too short to justify final conclusions concerning their value, several important observations have been made. Buckbrush checks alone cannot be expected to control gullies whose drainage areas are over 5 acres; in the larger areas other methods of control are needed. Gullies whose flow lines are so steep that checks would have to be almost on top of each other cannot be controlled by buckbrush.

The checks placed during the dry fall of 1936 and those placed during the 1937 season (a season of practically normal rainfall) have lived equally well. Though rainfall in the spring of 1937 was unusually heavy, the buckbrush has not been killed out by moisture in the gully bottoms.

To date, the buckbrush checks have been successful, and they are being watched closely for future developments. It is expected that the buckbrush will spread up and down the gullies. In discussing the dams, Dubois Creek project staff members list three advantages of the living structures: (1) They can be used in gullies surrounded by cultivated land; (2) they seem capable of stabilizing gullies in tree planting areas until the trees are large enough to take care of the erosion, at which time the buckbrush will be shaded out; and (3), perhaps most important of all, the use of buckbrush dams constitutes an erosion-control measure, which, because of its simplicity and economy, the farmers can put into effect on their own farms.



Position and use of wire and posts in buckbrush check dam.



REGION 6

Stabilizing the Dust Bowl

By D. A. Dobkins and Virgil S. Beck [1]

FROM the beginning, the major problem confronting those engaged in soil-conservation work in the Southern Great Plains has involved not only the stabilization of land severely damaged by wind erosion but the restoration of such land to profitable agricultural uses as well. The situation, which was the direct consequence of improper methods of land use, became acute during the extended drought period starting in 1931, when the average rainfall of 18 inches over a long period of years had decreased to 8 to 12 inches. Failure to use soil- and moisture-conservation methods had resulted in successive crop failures.

Millions of acres that had been producing bumper yields of wheat and other crops were deprived of their residue and became subject to blowing during the yearly period of high winds from January to May. Many fields lost topsoil to depths of 3 to 12 inches and hummocking resulted; while, in a few areas, notably at Dalhart, Tex., huge sand dunes were formed. Pastures in the vicinity of blowing fields were covered by the drifting soil, killing out the grasses and allowing these areas also to become subject to blowing.

AFTER studying the conditions, soil conservationists realized that special types of treatment would be required to restore the eroded lands to a point where a long-time erosion-control agricultural program could be put into operation. Some of these special treatments are here pointed out.

On severely hummocked fields where soil drifts were so high as to prevent use of ordinary farm equipment, it was necessary first to level the land to a point where it could be cultivated easily. During the emergency period it was imperative also that cropping systems be changed on most lands and that moisture-conservation practices be established over the whole area.

Wheat, the principal grain crop of the Southern Great Plains before wind erosion became so severe, no longer could be grown successfully without soil and moisture conservation.

In a majority of the wheatfields crop residues had been lost through successive crop failures; and since wheat seeded in the fall in fields lacking crop residue has little chance of maturing sufficiently to withstand the erosive action of high winds, the only alternative was the substitution of a crop better adapted to meet the emergency conditions.

FORAGE and grain sorghums, soil-binding crops which grow during the summer, were found to be suitable substitutes for wheat. These crops are of particular value because they mature fully before the high winds start blowing in the winter.

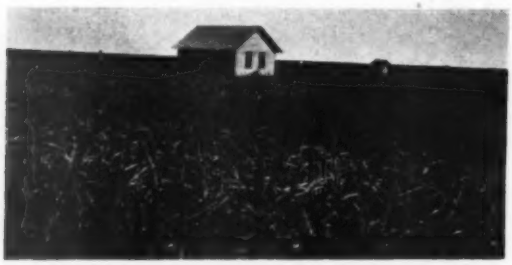
The light sandy soils, many of which prior to the period of severe wind erosion had been planted to corn, cotton, and beans presented another serious problem, as some of them were among the most severely damaged of any in the Great Plains region.

After leveling drifted fields, many farmers gave up the old cropping systems entirely and turned to grain sorghums. On many farms, however, it was found

[1] Information Section, Soil Conservation Service, Amarillo, Tex.

This wheatfield in the Stratford, Tex., project area experienced six successive crop failures. The blowing during the winter of 1936–37 left it severely hummocked.

advantageous to retain some of the crops and adopt strip-cropping plans with the non-erosion-resisting crops such as corn, cotton, and beans planted in alternate strips with the soil-binding sorghums.



The same field after adopting soil and moisture conservation practices in the spring of 1937. These included terracing and the planting of grain sorghums on the contour. Although the rainfall was less than 9 inches up to October 1, the crop matured fully. The field not only has yielded a profitable crop but now has a cover of stubble for protection during the blowing season.

As to the amount of sorghum stalk or stubble left on the fields as protection against blowing during the winter this depends on the extent of erosion in the particular area. In severely eroded areas only the heads of grain are harvested, while in the lesser affected sections a stubble of from 8 to 12 inches is found sufficient to furnish protection. In no instance has grazing on such fields been permitted, since removal of any part of the residue and the trampling of the field by livestock would aggravate the situation.

During recent dry seasons some effective water conservation was often necessary in order to obtain the first cover crop. In the semiarid plains, where the limited rainfall fluctuates widely from season to season and year to year, conservation of moisture usually is essential. On fields subject to loss of water by run-off, the land is now farmed on the contour, and, where necessary, supported by terraces. Experiment stations within the wind-erosion region have found that through this system of conserving moisture the wheat and grain-sorghum yields have increased 34 percent over a period of 11 years. Conservation of moisture increases the possibility of getting a crop and aids in leaving a good protective vegetative cover on the soil each year.

Experience in the demonstration areas of the Soil Conservation Service has proved that cash returns to the farmer using these wind-erosion control methods are greater than the cost of putting the practices into use. In addition, the farmer has protection against soil losses by wind erosion.

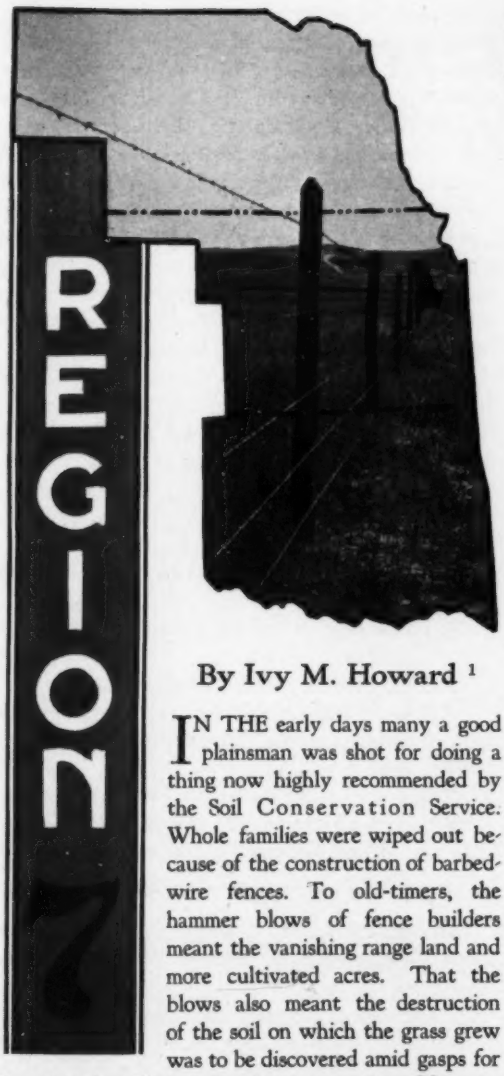
6

The first wind-erosion control project in the country was set up in August 1934, at Dalhart, Tex., at that time known as the Capital of the Dust Bowl. Since then, 26 other demonstration areas have been set up in the wind-erosion region which includes the Panhandle of Texas and Oklahoma, southwest Kansas, eastern Colorado, and eastern New Mexico. Progress in the restoration of blowing fields to profitable farming may be judged from results obtained on the Dalhart project.

When the Dalhart project was established in 1934, of the 28,765 acres taken under agreement, 23,841 had been damaged by moderate to serious wind erosion, while the remaining 4,924 acres were slightly eroded. At that time, the entire project area was subject to blowing. Soil- and moisture-conservation practices have been in use for 3 years, and today it is estimated that 25,025 acres are stabilized against blowing, while only 3,740 acres remain subject to wind erosion. These results have been obtained with rainfall of only 12.12 inches in 1935, 9.37 inches in 1936, and 12 inches to October 1, 1937. The long-time average for the project area is 17.72 inches.

On wheatlands where the accumulative effects of erosion are serious, the planting of sorghums will continue until such time as conditions will permit a safe return to wheat production. Once the land is restored to a condition suitable for wheat growth, this crop may be resumed and continued until insufficient moisture and lack of proper residue again may dictate a return to sorghums as a safety precaution against wind erosion.

(*Continued on p. 167*)



Soil-Saving Fences

By Ivy M. Howard [1]

IN THE early days many a good plainsman was shot for doing a thing now highly recommended by the Soil Conservation Service. Whole families were wiped out because of the construction of barbed-wire fences. To old-timers, the hammer blows of fence builders meant the vanishing range land and more cultivated acres. That the blows also meant the destruction of the soil on which the grass grew was to be discovered amid gasps for breath in dust-filled air by a later generation of farmers. And, strangely, it is the farmers of this generation who are now engaged in the construction of barbed-wire fences to save what is left of the range.

THROUGHOUT the Central Great Plains region, from the corn-producing counties of northern Nebraska to the cotton-growing sections of southern Oklahoma, fences are being used to save soil. Fields enclosed with contour fences are fields that are easily tilled on the contour. Fenced gullies, it has been found, are gullies that do not grow. Fenced farm ponds are ponds with dams, shore lines, and spillways not damaged by erosion. And fenced wood lots are wood lots from which raindrops never rush away as silt-laden flood makers.

"See those gullies?" Frank Kalina, Pawnee County, Nebr., points toward a nearby hillside covered with coarse vegetation as he asks the question. "A barbed-wire fence was all it took to stop them."

Fences to keep livestock off eroded acres is the price Mother Nature asks for her cooperation in providing a soil-holding cover of natural vegetation for the areas. That the price is not considered exorbitant by Central Great Plains farmers who are cooperating with the Soil Conservation Service is shown by the fact that up to July 1, 1937, more than 11,000 acres of eroding land in Oklahoma, Kansas, and Nebraska had been fenced for the primary purpose of protecting soil by protecting plant cover.

CONCENTRATION of livestock is responsible for a large part of Central Great Plains erosion. That protection of the eroded areas from livestock will retard soil movement is being demonstrated on hundreds of farms where eroding areas are now fenced. These demonstrations show that wherever plant cover is destroyed or the climax type of vegetation thinned, a natural process of restoration sets to work as soon as the cause of disturbance is removed. This means that if land is protected from grazing, fire, and concentration of run-off water, it will soon be covered with soil-holding natural vegetation.

On fenced areas where the original vegetation has been completely removed, a temporary cover of weeds

Fence placed atop terrace as field boundary. Road leads to farmhouse, on contour. Even the farmer's telephone line follows the contour.

[1] Section of Information, Soil Conservation Service, Salina, Kans.

appears. This cover is followed in order by the different types of vegetation according to the character of the land and nature of the climate. If trees grew on the land before it was plowed, shrubs begin to appear within the first 2 or 3 years. These are followed in time by trees, which are later replaced by other kinds of trees. Finally there develops a woods composed of the same kinds of trees as were cut off the land before the field was first plowed. On the other hand, if the field, or a part of it, was in prairie grass before it was plowed, the fences permit the return of the original grasses.

That vegetation is important in the control of erosion is shown by tests conducted by Dr. J. E. Weaver of the University of Nebraska. Results show that there was no water lost as run-off when 2½ inches of water was applied in 3 hours to a good stand of native prairie grass 3½ inches high. The same amount of water applied to a pasture on which the grass stands had been reduced by overgrazing resulted in 29 percent run-off, with the run-off starting 5 minutes after the first water was applied. All water leaving the closely grazed pasture area was muddy. No erosion occurred on the land protected by prairie grasses, while on the overgrazed pasture area the soil loss was 165 pounds per acre.

Fencing eroding areas and letting Nature provide the soil-holding cover ensures permanent stabilization of soil. Trees, shrubs, and grasses selected and planted by man may give quicker protection than can be obtained by natural process, but unless the artificial plantings are well adapted to their particular locations they will be only temporary. Natural revegetation must be depended upon to provide permanent erosion control.

Protecting eroding areas by the use of natural vegetation is not land retirement; it is the rededication of the land to the production of the crops for which it is best adapted. A gully controlled by natural vegetation may produce profitable crops of timber and farm wildlife; a steep slope, naturally vegetated, may, with the exercise of a little caution against overgrazing, be made to furnish economic crops of pasture or prairie hay. Stream banks with native trees and shrubs growing on them make ideal homes for farm wildlife and provide valuable crops of timber. Obviously, then, fencing land to protect natural vegetation is an important step in ensuring wise land use.

On cultivated fields of the Central Great Plains region fences also play an important role in soil conservation. They make possible rotation grazing of pastures; they provide a simple means of preventing overgrazing of supplementary pastures; and when located on the contour they solve the baffling problem of point-row elimination. Other advantages of contour fences may be pointed out. For example, on the farm of J. D. Pettit, Carter County, Okla., a relocation of field division fences made possible an increase of 80 yards in the length of rows. This allows more rapid cultivation due to a reduced number of turns. Another benefit, cited by Gans Brown, Kingman County, Kans., is that the contour field boundary roads may now follow the field boundary fences. In Allen County, Kans., Beatty Ray points to fields on his farm as proof that contour fences can be used to divide a farm in such a way that the fields will not have both wet and dry areas in them at the same time. These and other benefits derived from the use of contour fences may be summed up as follows:

1. Point rows are eliminated.
2. Longer rows are possible.
3. Contour fences serve as guide lines for contour farming.
4. Fields may be divided according to soil characteristics and slope.
5. Field boundary roads may follow contour.
6. Use of strip cropping is encouraged because strips of erosion-resistant crops may be more even in width.
7. Livestock paths along fences will be on contour.
8. Levies are created, due to back furrowing, that will hold soil and water in periods of torrential rainfall.

In the Great Plains fences are important in connection with all erosion-control methods. For example, the thousands of terraces in Oklahoma, Kansas, and Nebraska would be worthless if the fences were removed from around their terrace outlet channels. Imagine too, the havoc that would ensue if meadow strips which are depended upon for control of water from terraced fields were exposed to livestock.

As for farm ponds, much has been said about their value in soil and water conservation and it is generally conceded that the best ponds are fenced ponds. Fences give farm ponds protection from erosion by ensuring a protective cover of vegetation on the pond dam, on the shores, and on the spillway. Also, many ponds have large fenced areas immediately above them to ensure a good growth of silt-settling grasses.

Grass used for erosion control needs protection and for this reason fences are extremely important in the Central Great Plains region.

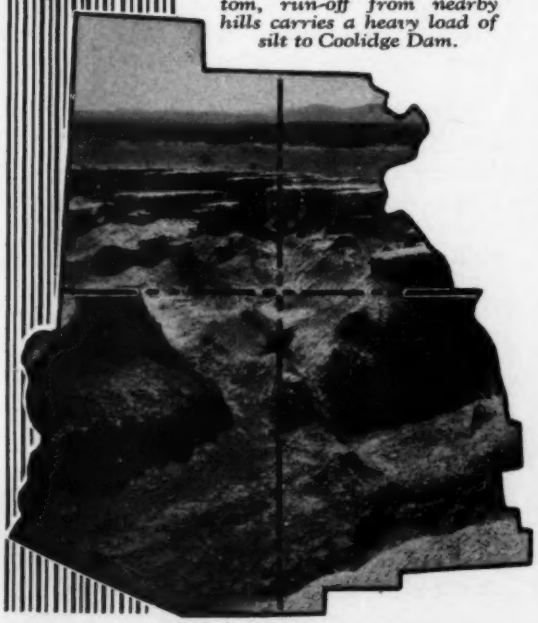
REGION 8

Grass and Water Storage on A Quarter-Million Acre Ranch

By Kenneth M. Gapen [1]

IN THE low rainfall country of southeastern Arizona Rancher William Ellsworth and his sons operate almost a quarter-million acres of range—the biggest unit of land under cooperative agreement in any region of the Service. Ellsworth is one of the most progressive and forward-looking ranchers in range areas where the carrying capacity is low. He was one of the first to realize the need for adopting different grazing practices to save the ranges and the range livestock industry.

Active gully erosion on San Simon. Formerly a luxuriant tobosa and sacaton flat. Without grass in valley bottom, run-off from nearby hills carries a heavy load of silt to Coolidge Dam.



The Gila River flows east to west across Arizona. From Solomonville, a little town near the Service's Upper Gila district headquarters at Safford, the quarter-million-acre ranch stretches southward about 30 miles up the San Simon Valley. Its watershed drains northward into the Gila River near Solomonville.

A check up on the changes that have come about on the ranch land in 51 years indicates the importance of Ellsworth's cooperation and leadership in establishing soil- and water-conservation measures.

RANCHER Ellsworth says that for some time after he came in as a partner in 1886, most of the land within 1 to 6 miles of the bottom of the valley was covered with sacaton, tobosa, and other native grasses. A part of the area was a natural hay meadow where the hay was cut, stacked, and fed out during the winter and through summer droughts. Water holes where the stock watered and stood during the summer rainy seasons were scattered along the San Simon; but nowhere along the valley was there a wash or creek. In the winter the stock found plenty of forage on the slopes along the sides of the valley.

Thousands of calves were branded yearly in the early days. Even as late as 1918, almost 2,000 calves were marked during the round-up.

DURING intervening years, however, Ellsworth has seen a steady change come over his ranch land. Today, an arroyo 20 to 30 feet deep and 100 to 600 feet wide from bank to bank cuts its way along the bottom of the valley. Water flows in it only 2 or 3 months out of the year. Practically all the good grass cover and feed is gone. The rain falling on the slopes and valley drains across the land into the arroyo and flows wildly down the wash to the Gila River.

[1] Associate information specialist, Soil Conservation Service, Albuquerque N. Mex.

Silt from San Simon and other alluvial valleys is carried by the Gila River and deposited in the reservoir behind the Coolidge Dam. Silting costs downstream farmers more than 50 cents per acre-foot and causes excess evaporation.

As it flows across the range the water picks up soil, cuts tributary washes deeper and farther back each year, and digs the soil from underneath the banks of the main arroyo and tributary washes. The sudden, heavy flash flows carry the soil down and dump it into the Gila.

What has happened to all that grass? Has the climate changed? The rancher's answer is significant in that it indicates the range practices responsible for similar changes all over the Southwest region, especially in the alluvial valleys.

"No, the climate has not changed," declares Ellsworth. "In the old days the open range and the valley meadows and grasslands got an average of 7½ to 10 inches of rain each year, just as they do today. We old-timers had our droughts just as today. But water was the big reason why the grass on the valley floor was so luxuriant. The water from the rain on the slopes drained slowly down the sides of the valley through the grass and soaked into the soil. Water that made the valley grass grow luxuriantly was really equal to about 50 inches of rain.

"Some of it collected in the scattered water holes during the summer rainy seasons. The cattle out on the adjoining hillside ranges came down 6 to 8 miles to the grassy valley bottom for water during the summer rains, staying there until the rainy season was over and the water holes became shallow or dried up. While they were there, they grazed heavily.

"But heavy grazing was not the immediate cause of the big arroyo. Along the valley and across my land ran the old wagon roads traveled by the countless 8- or 10- or 12-horse teams of the freight haulers. Many wagon trips deepened the wheel ruts until the run-off water washed down and concentrated in the wagon roadbed. When one set of ruts got too deep to drive through, the freighters moved over and dug another set to gather more water. These ruts of the old roads," the rancher explains, "were the beginning of the San Simon wash of today.

"In later years a railroad bed was built near the wagon road that was already fast turning into an arroyo. It was so near to the wash, too, that the railroad drainage helped to dig it deeper and wider."

"During the years, the grass got thinner," he added. "The water flowed down the slopes faster, cutting the side washes deeper and washing more soil into the arroyo."

Those who live where pasture grass is deep and water plentiful may not understand what has happened. Others know that the natural balance between soil, water, and vegetation in the Southwest is very delicate. The things that have happened on Ellsworth's range, as on most southwestern ranges, have upset that delicate balance.

It is important to the rancher that the valley flats will carry less than 10 head of stock now where there were 100 or more in the old days. But Mr. Ellsworth reminds us—"There were too many cattle on the San Simon range in the old days." The result is that he doesn't have the grass that he once had. The water swiftly runs off the range land because the good grass cover is not there to slow it down. Soil is lost, water is lost, and the grass plants struggle along in continual drought.

This is also important to irrigation farmers downstream. The silt from the San Simon ranges is deposited in their irrigation canals and ditches and is a big factor in slowly filling up San Carlos Reservoir behind Coolidge Dam. The water coming out of the wash only a short time each year comes in flash floods that cannot be handled by the Gila River.

Townspeople also have a deep interest in what is happening on the range, especially those who partly or wholly depend on stock raising and irrigation farming for livelihood. They are being increasingly effected because the more frequent high peaks of the Gila and other rivers in the Southwest are doing greater flood damage. And they now have more valuable property to be damaged.

Ellsworth, who saw what was happening, wanted to save the land for the future. The Soil Conservation Service surveyed his ranch holdings of private, State

(*Continued on p. 168*)

REGION 9

Rows of corn every 5 rods across a 40-acre potato field in 1937. The strips are left standing after the potatoes are dug, to act as windbreaks, to accumulate snow moisture, and to provide food and shelter for wildlife.

Wide-Row Plantings of Annuals

By Frank B. Harper [1]

THE deep, black soil of the Red River Valley in eastern North Dakota produces some of the best potatoes grown in the United States. Hundreds of carloads move on to the markets every year. It also brings forth good yields of wheat, flax, corn, and other crops.

That same deep, black soil is susceptible to wind erosion. Many miles of fence rows in the old Agassiz lake bed of glacial days often are drifted full of blown soil, swept before high winds that blow across the level land throughout several months of each year.

[1] In charge, Information, Soil Conservation Service, Rapid City, S. Dak.

THE farm of William Lewis, 5½ miles northwest of Park River, N. Dak., is in the midst of the wind erosion area. When it came time for this farmer to plant his potatoes in the spring of 1936, he and technicians from the Soil Conservation Service project decided to try a new application of the wide-row planting principle. The plan was to plant a few rows of corn every 5 rods in the potato fields. It was hoped these would serve as windbreaks to protect the crop strips from the blowing.

Potatoes constitute a highly specialized clean-tilled crop. In order that every drop of moisture be made available for the tuberous crop, all weeds and other vegetative growth must be kept down. When harvest time comes in September, the potato vines are dried up. After the tubers are dug, the topsoil is left absolutely void of anchored vegetation, and is finely pulverized as a result of the cultivation and harvesting. It consequently is in the best possible condition for wind blowing.

Tame sunflowers serve double purpose of holding snow moisture on field and providing food and cover for wildlife. Their strong stalks stand up against the wind and snow.

WHEN fall, winter, and spring winds blew over Mr. Lewis' potato field, they encountered the tall-growing rows of corn, spaced in such a fashion —at right angles to the prevailing wind direction— that the ground currents were quite completely broken up and deflected upward where they could not start soil movement. Park River Soil Conservation Service technicians watched the performance closely and with great interest. They observed that little or no soil movement occurred on Mr. Lewis' potato field. They noticed, as winter progressed, that snow was held on the fields in drifts around the corn rows, and that it stayed there and melted in the spring, adding valuable moisture to the soil. They also saw that game birds lost no time in finding the outdoor cafeteria and in taking advantage of the corn rows for shelter and travel lanes.

"That's what we have been looking for," said Project Manager Lyness G. Lloyd when with his staff he sat down to work out 1937 farm plans. The project technicians agreed. Cooperators in the area took to the idea readily.

Reasoning that if a few rows of corn were effective in helping control soil movement on potato fields, the Park River technicians concluded that this or other tall-growing annuals at most could do no harm if used in conjunction with other cropping plans. Consequently, many of the 1937 crop systems for the area called for from 2 to 4 rows of corn in potato fields, or some combination of corn and cane, Sudan grass, or tame sunflowers, between strips of land being summer fallowed, either on the contour or crosswise to the prevailing wind.

As it happened, the project technicians and their cooperators were not the only ones in the valley with sharp eyes. News of the practice spread, and this year a considerable number of farmers around Park River and Fargo followed the lead of cooperating land operators in the wide-row annual plantings.

To date the widest use of the annual windbreak principle is on potato ground and clean fallow. Increasingly popular, also, is the planting of a row of sunflowers on either side of shrub and tree windbreak plantings. Taller growing than the maize crop and hardy enough to withstand winter blasts, this woody-stalked plant stands up well through winter snows and wind.

The annual plantings serve three major purposes: (1) They deflect the wind upwards and thus shield adjacent soil from blowing; (2) they increase winter moisture retention by holding snow that otherwise would be blown away; (3) they provide wildlife food and cover.

Some cooperating farmers have seen fit to harvest at least part of the grain or seed produced on these wide-row strips, obtaining at times a considerable amount of corn on a half section or so, or a handy supply of chicken feed from sunflower heads.

This contour strip-cropped field near Park River, N. Dak., had the advantage of going into the 1937–38 winter with two rows of corn left standing as buffers to deflect the wind upward from the soil and to hold the snow. A typical water-disposal plan for a South Carolina farm, showing where terraces will drain, where meadow strips and outlet channels are needed, as well as other measures to give the farm eventually a complete system for controlling run-off waters.

Gold in the Grass Roots

By Harry E. Reddick [1]

Panning gold.

A WISE old prospector once stated that most of the big gold discoveries were not made by the prospectors themselves, but by their burros shaking pay dirt from the grass roots as they browsed. Granting that he may have been a little modest in the defense of his own calling, it is still quite true that there is more gold in the roots of the grasses than has yet been found in the ledges or veins beneath the surface.

The area that lies to the east of Sacramento, Calif., including the Mother Lode district, has long been famous for the gold it has produced. This section of the State provides two striking examples of the accumulation of wealth through grass as a medium.

A few miles out of Sacramento to the eastward lies a rolling plain criss-crossed with great wind-rows of rocks 30 feet in height and equally as wide. This is the area where the dredgers work. Huge, hungry machines that float on ponds of their own making eat away the land to a depth of 20 feet or more and pile the washed rock behind them as they creep forward. Here is an example of what gold can do to a country—gold in the pockets of the present landowners, but for the future generations, a pile of rocks forever.

The city of Placerville nestles among the pine-clad foothills of the Sierra Nevada range some 50 miles to the eastward. Region 10 has a conservation area located there, and the orchards in this section are proof that the minted gold from crop returns is more lasting than that which is washed or mined from creeks or ledges.

Placerville, known in the days of '49 as "Hangtown," was for many years a roaring placer mining camp—with its gamblers, its boom times, and its two-gun characters who frequently played their last part doing gymnastics at the end of a hemp rope with the vigilantes as an encouraging audience.

Today, mining is of secondary importance around Placerville, and thousands of acres of the red earth that was formerly sluiced down over the riffles armed with quicksilver now are producing pears, plums, and peaches. In spite of the fact that mining is no longer Placerville's medium for prosperity, the gold-in-the-grass-roots idea still holds true, because a permanent cover crop of well-rooted grasses has proved to be the best way to keep the hillside orchards in production.

Although pears, now the principal crop around Placerville, were first introduced into California by the Mission Fathers as early as 1769, the cash value of pears and peaches probably hit an all-time high during the early days of the gold rush when it is recorded that the yield from one tree in the locality was worth $1,000 and single fruits sold for as high as $3 each.

[1] Regional conservator, Soil Conservation Service, Santa Paula, Calif.

Placerville farm land that has retired itself.

Many of the present-day aspects of fruit growing in Placerville can be traced back to the influence of the early mining activities in the region. In the first place, the start of fruit growing in the district was due directly to the demands for fresh fruit by the miners rather than for supplying eastern markets as is the case today. Many of the farms owe their location to the fact that the ground had been cleared of its pine trees

Downhill irrigation has caused much damage in the Placerville area.

by miners in search of timber for tunneling operations, or in other instances, because old placer-mining flumes could be used for irrigation.

One of the present problems confronting the Soil Conservation Service in this district is the outgrowth of a custom dating back to the days when "miner's inches" of water from the stream were allotted to each claim. This miners' measurement of water, when applied to orchards, has resulted in the farmers not having enough water at one time to irrigate in the most efficient manner. Instead of having available a large head of water for a few days and devoting his entire time for the short period to the task of irrigating, the farmer must shift his small stream every day or two; and because the flow is constant, he does not give it the attention that he would if the supply were more abundant for a shorter time.

Storage basins to enable the farmer to hold the water off his land until he has accumulated enough to permit flooding or completing his irrigation at one time have been suggested as a remedy; and some of the growers have formed agreements whereby one can use the allotment of the others for a short time and then pass it on.

Another difficulty is the loss of water due to leaks in flumes, seepage, and evaporation. These losses, estimated to be as high as 15 percent of the water entering the flumes at the stream, are being taken care of by the installation of concrete pipe lines. These pipe lines are made up of sections about 3 feet in length and of varying dimensions to fit the volume of water to be handled. The process of making these pipe sections has been highly developed in California and consists of tamping a fairly dry concrete mixture into sectional molds. Special fittings, such as head gates, vents, and outlets, are cast and later fitted with metallic parts wherever there is wear or where moving parts are required.

The use of concrete pipe in the irrigation systems has been recommended by the Soil Conservation Service because indirectly it makes possible the planting of permanent cover crops on the steep hillsides. Surveys of the area showed that, due to the orchards being planted on the square or diamond, with the irrigation down the steepest part of the slope, ranging from 10 to as high as 30 percent in grade, a great deal of soil was being lost, not only from the winter rains after the volunteer cover crop had been disked under but also from the cutting action of the irrigation water itself. It was immediately recognized that permanent cover crops would furnish the desired protection; but there was the frequently encountered objection that such crops required too much water to permit their use.

After further study it was determined that by conveying the water through concrete pipe lines rather than open ditches, a sufficient saving could be made in irrigating water to more than offset the amount used by the permanent cover crop. The prevailing practice among many of the cooperators now is to plant Italian

rye grass, clover, alfalfa, or bluegrass, and to mow or lightly disk this in the spring to prevent further consumption of moisture, leaving the roots intact and ready for the first fall rains.

In connection with this type of irrigation, the unusual practice of running furrows or "sideboards" up and down the slope at frequent intervals is often adopted. After they are seeded, these furrows prevent the water on the flooded areas from concentrating on one side of the slope and cutting gullies.

Cover crops are by no means the only preventive measure being used by the Soil Conservation Service in attempting to stop erosion in this locality. Basin listing, contour furrows, and wherever possible the changing from down the slope irrigation to across the slope are being recommended.

Unlike the early settlers in this community who tried to get the maximum erosive effect out of the water in their placer mining operations, the modern Placerville farmer is doing everything possible to use the water in a way that will prevent erosion. This is another example of a western community where irrigation practices have been the cause of a great deal of soil loss, and where a change of irrigation practices has become the objective of the Soil Conservation Service in that area.

The change of attitude on the part of the residents and surrounding farmers toward the Soil Conservation Service and its objectives has been marked indeed. In the beginning, many of the old timers living on places deeply cut by gullies were inclined to scoff at

Back and forth across the plains creep the dredgers, turning grasslands into rocky wastes.

the idea of the Federal Government advising them about the dangers of losing their soil. Today, there is recognition of the dangers of erosion that makes a 3-inch rill down a cultivated slope a topic of discussion on the street and sufficient justification for the owner to call on the project manager.

Not only are they conscious of the fact that there is a problem. They are so eager for help that they readily agree to furnish most of the labor and 90 percent of all material in order to get the work done. Although it will be a year before this project goes on maintenance, there are already more surveys requested by cooperators than the project personnel can take care of.

There is still gold in the grass roots of Placerville as can be attested by Soil Conservation Service employees who have panned "color" in their own back yards. But the real wealth that is bringing life and prosperity to the community again can be found in the carloads of golden pears that follow the same trail once used by the "forty-niners" as they go down out of the mountains to the eastern markets.

WATER DISPOSAL PLAN

(*Continued from p. 150*)

from the gully where necessary to check erosion, and the filling up of small gullies and terracing across them.

Relocation of roads that otherwise would run across planned terraces or that may be required for water-disposal outlets are shown in the plans. The plans also show the engineer's rough estimate of required terrace locations. While usually it has not been difficult to determine the draws and edges of fields where meadow strips and outlet channels should be placed, often it is not so simple a matter to show the terraces in detail. The important thing in establishing the waterway, however, is determining where the terraces will drain, and this the South Carolina engineers have been able to do 90 to 95 percent correctly, Downing says.

With emphasis of the Service shifting to cooperation with organized districts, the engineers look upon the water-disposal plan as an excellent opportunity for extending technical assistance to a large number of farmers. Where the Service renders only technical assistance, we must depend on the farmer to carry out the plans. The South Carolina engineers say that farmers can and will carry out the water-disposal plans, because each plan is such that the farmer can clearly picture the complete water-disposal needs on his farm, and he can do the work as he finds the time.

STABILIZING THE DUST BOWL

(*Continued from p. 158*

On the sandier soils, the strip cropping of non-erosion-resisting crops with sorghums will be continued, with an annual rotation of the strips.

With this cropping system in operation and with full utilization of the water where it falls, there should be little danger from wind erosion in the future.

STRIP CROPPING IN OHIO

(Continued from p. 152)

The Salt Creek demonstration area of the Soil Conservation Service, the first to be established in the State, must be given credit for really launching the new era in hill culture. Strip farming, as Ohio knows it today, was unknown in Muskingum County when the project was launched early in 1934. More than 400 farms in the county are being tilled in strip fashion this year, and the demonstrations provided by these farms have formed the spearhead of the advance. Almost every county agent in the hill country has brought farmers in to see for themselves just what those alternate contour bands of corn and meadow are doing. From these tours has sprung a new confidence for thousands of farmers who have no level land to cultivate, and who must make their living from the slopes.

The spread of strip cropping on an extensive scale followed the establishment of additional projects and the allocation of a score of C. C. C. camps to the Service. The extension soil conservationist and the Ohio State University extension agronomists, alert to the possibility of strip cropping as the solution to the erosion problem, cooperated enthusiastically with county agents and with farmers. By 1936 systematic strip farming was being demonstrated in every section of the hill country, and it continued to spread.

Farmers began demanding help. County agents were far too busy to meet all such requests and keep up their normal work at the same time. The stage was set for the next act in the spread of strip cropping. In November 1936 the Soil Conservation Service, cooperating with the Ohio Agricultural Extension Service, set out to carry the gospel of soil conservation to southeastern Ohio farmers outside project and camp areas. To meet the demand, R. L. Bazler, conservationist, was delegated to re-plan those farms recommended by the Agricultural Extension Service and the county land-planning committee. Twenty-four typical farms in 12 hill counties have been selected as demonstrations, and the initial success accorded this phase of the work portends expansion of the experiment.

By midsummer in 1937 more than 21,000 acres within project and camp areas had been strip cropped. From a permanent standpoint, more important was the fact that farmers in at least 46 counties in the State had adopted this type of soil conservation.

But what of these farmers who have adopted the measure voluntarily? Will they continue the practice? Their remarks are singularly uniform. That from Wayne Thompson, Monroe County, is typical: "It's a lot easier to plow than before. The team does not have to drag the plow up hill, I can plow more ground now, and I am not as tired at night. It has stopped the washing."

It's the same with tractor operators. They admit freely that strip cropping saves time and labor costs. And when they harvest 60-bushel corn from a 20-percent slope, they tell the neighbors who have been watching those crazy bands which have become the all-year fashion for Ohio hill farms, what strip cropping can do for their sloping cornfields.

GRASS AND WATER STORAGE

(Continued from p. 162)

leased, and public-domain range, to find out how many cattle the land would carry. In the Southwest, the first step in protecting the range from soil erosion is a readjustment of livestock numbers to fit carrying capacity. This step in management is a prerequisite to operations. Grazing control gives the grass on the range a chance to come back. This recovery takes time—much time in a badly depleted, low rainfall area.

The range survey was made on the ranch in 1935. The next year the stocking of the range was reduced to the safe carrying capacity as indicated by the survey. Fifty-eight miles of fence was built to keep livestock from trespassing on the controlled range, and as an aid to proper distribution of cattle over the range. The next step was the construction of 14 stock water tanks for proper distribution of water supply.

The range surveys showed that the entire Ellsworth ranch would carry about an average of four head of cattle to the section. Some of the sections were so bare of forage that grazing capacity was nil. Some were better grassed and would carry 16 head a section or more.

Ellsworth had four sections of range along the bottom of the valley. He had fenced this pasture 20 years ago and had used it wisely and protected it from soil washing through the years. These four sections were covered with an excellent stand of tobosa and sacaton grasses that would easily carry 20 head of cattle a section. During the summer rainy season they would feed many more cattle. To the Service surveyors this was an indication of what widespread management and improved cover can do in controlling erosion and feeding the cattle.

(Continued on p. 170)

Above—Hay crop grown in a gully, seeding consisting of alsike, brome, meadow fescue, and redtop.

Below—The way straw farming looks most of the time.

Straw Farming

A one-way disk plow at work.

By C. R. Briggs [1]

THROUGHOUT the past, straw farming has many times demonstrated its value. It "puts back" as compensation for "taking off" the land. When the straw in the rotting process becomes humus it improves the soil's fertility and water-holding capacity. At the same time it conditions the land so that it works easier. Also, in the blow country of central Washington and along the Columbia River in Oregon, straw farming is considered one of the most effective methods for pinning down the land.

In the Palouse hills, straw farming, combined with two other practices—rough tillage and cross-slope cultivation—is now employed to prevent washing. LET us see these three cultivation practices at work on the farm of Elmer Meiners, 6 miles east of Walla Walla, Wash. In the first place, Meiners spread the straw on all his fields using a spreader on his combine harvester. In the fall of 1935 he chiseled 13 acres. An old plow beam with hardened point was used to break up the soil, down through a compact layer to a depth of 12 inches. The straw was left to lie as it fell on the top of the land.

An adjacent 25 acres was worked with a one-way disk plow, leaving the straw partially anchored and forming myriads of small obstructions to water racing over the surface, and at the same time providing an

[1] In Charge, Information, Soil Conservation Service, Spokane, Wash.

(*Continued on p. 170*)

BOOK REVIEWS AND ABSTRACTS

By Phoebe O'Neall Faris

THE EFFECT OF LAND USE AND MANAGEMENT ON EROSION. By E. H. Reed and J. I. Falconer. Ohio Agricultural Experiment Station, Wooster, Ohio. July 1937

A report based upon a study of 100 farms located in four Soil Conservation Service demonstration areas in Ohio. The data were obtained by the survey method in 1936 and include information from land owners and tenants, past and present, concerning soil types, slope acreage, erosion, cropping and animal units, income from crops and livestock, land cover, cropland distribution by slopes, erosion-resistant and erosion-favoring rotations, use of fertilizers and lime, tenure and mortgage, yields and income. The object of the study was to determine to what extent quality of farming and management, as well as organization and land use, are factors of importance in the control of erosion on farms with similar soil type and topography under similar climatic conditions. The study was a joint project of the Ohio Agricultural Experiment Station and Region 3 of the Soil Conservation Service. The 100 farms studied are located in the Salt Creek, Muddy Fork, Granny-Dry Creek, and Indian Creek areas.

STRAW FARMING

(*Continued from p. 169*)

equal number of leadways for the water to follow down into the soil.

Then there was a third field on which the stubble was burned, leaving the land to lie bare over the winter.

Most of the moisture that makes the wheat crops of the Pacific Northwest comes in the winter; therefore, in the spring of 1936, these three fields stood ready as demonstration plats to show what straw farming, when combined with rough tillage and cross-slope cultivation, would do in the way of holding the moisture for the spring-planted crop.

The story of the straw on the 13 acres of chiseled land can be told briefly: There was no run-off. From the 25 acres which had been worked with the one-way disk plow a little water trickled and oozed off the lower end. The burned plowed land was cut into ribbons. Every 3 feet the run-off had washed out rills that averaged 4 inches in width and 3 to 6 inches in depth. The average soil loss from this field would amount to approximately a foot of topsoil in 40 years.

The comparisons seem to favor chiseling. The expense factor enters here, however, since after chiseling the seedbed must be prepared as an extra operation. The one-way disk plow does a complete job and does it at less expense.

This demonstration, along with others, has carried conviction to farmers both on and off the projects. At Walla Walla, where Meiner's farm is located, three straw spreaders were available when the project was established in 1935. (Here it is well to remember that the straw must be spread behind the combine harvesters before it can be worked into the soil with any implement.) Now the 44 cooperators have 20 spreaders and these serve everyone. Eighty percent of the land in the community is "straw farmed." On the Pattit Creek project, 20 miles from Walla Walla, the one straw spreader that was available in 1935 has been put to work again and 15 others have been purchased. Nine one-way disk plows adequately serve the whole community. In the Moscow-Pullman area, crop residues are being utilized on 40,240 acres of land.

GRASS AND WATER STORAGE

(*Continued from p. 168*)

It would take time to bring the grass back on the ranch land through grazing control alone. To help check soil washing and protect the grasses, some of the worst gullies were worked on. In some places the water was spread out over the land, and fences and stock-water tanks helped distribute the home stock and kept out trespass stock. All these mechanical devices aid in the control of erosion and prevent damage to irrigated lands and silting of reservoirs in the Southwest range country.

Mr. Ellsworth tells us that his range is already improved. He believes in properly stocking and managing range land to improve the cover to raise livestock more efficiently, and to check soil and water losses.

He understands that the tremendous quantities of silt washed into the reservoirs and irrigation systems come from the banks of the meandering washes, the tributary gullies, and the widening arroyo channel on his holdings and on other ranges of the lower valley.

Stockmen, farmers, and townspeople are all directly concerned with and affected by soil erosion in the Southwest.

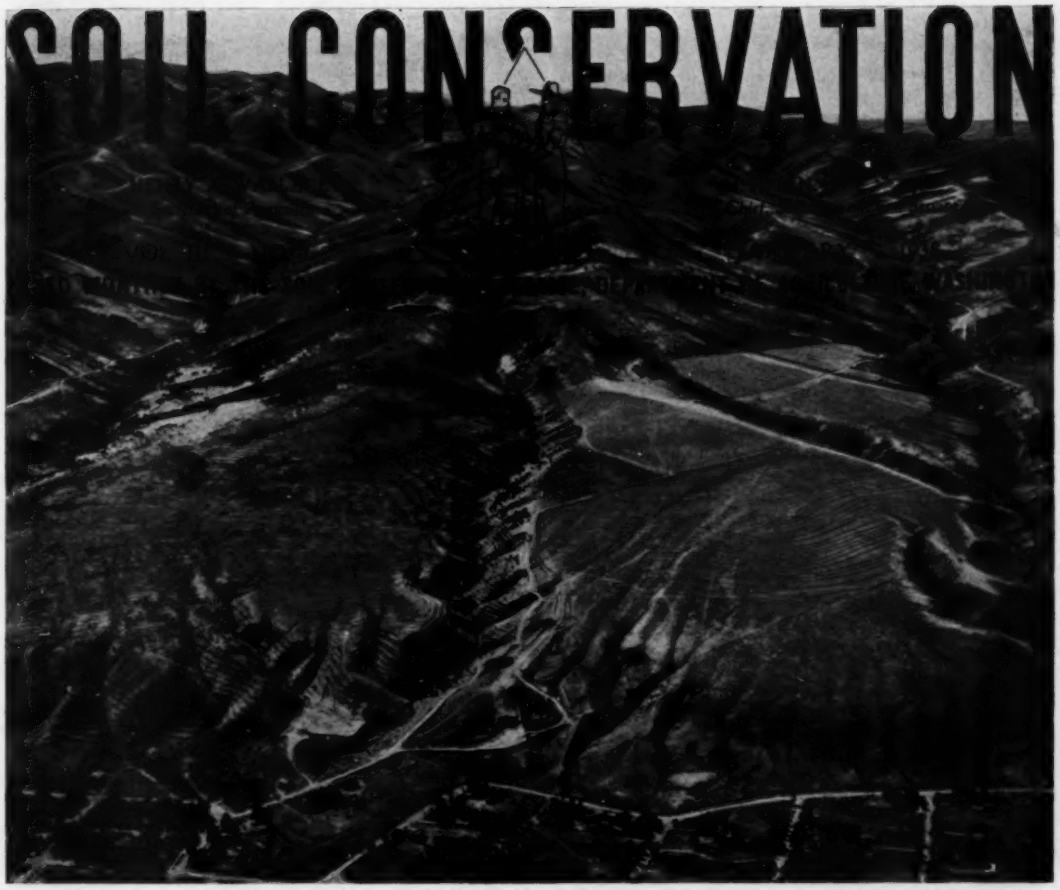
MEADOW OUTLET STRIPS

(*Continued from p. 154*)

outlet strips. The strips vary in size from less than 1 acre to the largest in the region (located in the Minden, La., C. C. C. camp area) which is 4,300 feet long and handles the drainage from 185 acres of land.

Where they are fenced, and if carefully managed, meadow outlet strips may be grazed. Stock should never be allowed on the strips during rainy weather, however, and must not be left at any one time long enough to form trails or to injure the vegetative cover. Because of the extra water that is made available to pasture grasses and clovers growing in the outlet strips, unusually good yields of hay are cut from them.

U. S. GOVERNMENT PRINTING OFFICE: 1937



Aerial view of terrain adjacent to City of Pocatello, showing slopes protected by contour furrows. (*Photo by courtesy of 41st Division, Aviation, Washington National Guard.*)

620 Miles of Contour Furrows Stabilize the Pocatello Hillsides

By Glenn M. Querna [1]

IT is now 2 years since soil conservation workers from Camp Bannock, at Pocatello, Idaho, began organizing hillside defenses against flood-causing run-off water on the slopes surrounding the city. Today the results of the project point toward a successful conclusion, with only a few years more work needed to assist nature in establishing soil-holding vegetation.

Weapons employed in the battle are few but effective. Contour furrows, 620 miles of them, constitute the first-line defenses. Water hold-back assists the regrowth and spread of native range vegetation. Torrential rains are put to useful work, rather than being permitted to carry silt and debris down into the city.

THE contour-trench system of flood and erosion control was first developed and used by Reed W. Bailey, director of the Intermountain Forest and Range Experiment Station, on the Davis County watershed in northern Utah.

Contour terracing to save soil and moisture is nearly as old as agriculture itself. Although identical in principle, the practical application of these contour

[1] Section of Information, Soil Conservation Service, Spokane, Wash.

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The "Pocatello plow" designed and perfected on the project. Note the hydraulically operated damming attachment at the rear.

Another view of contour furrows above the city of Pocatello.

Contour furrows filled with water after torrential rain of July 31, 1936.

structures to flood and erosion control on high range watersheds in the semiarid West involved a number of changes both in design and methods of construction.

Technicians at the Pocatello camp decided on the construction of contour furrows at intervals and of capacities to hold 50 percent of a 2-inch rain over a 24-hour period. Hand-built furrows proved to be entirely effective in preventing run-off on a small watershed so treated, but their construction was slow and costly. Horse- and tractor-drawn plows, disks, and furrow-builders were tried. Shoes were made for bulldozer blades to hold blade ends in proper trenching

(Continued on p. 177)

The Living Soil

By Selman A. Waksman [1]

THE upper layer of the earth's crust, namely the soil, in which grow our cultivated and uncultivated crops, does not represent a dead mass of disintegrated residues of rocks intermixed with dead remnants of the numerous plants and animals living in or on the surface of the earth. The upper layer of the soil, while it appears a dead mass, nevertheless furnishes a home for numerous forms of life. As a result of the activities of these organisms, the soil is able to supply food in an available form to the yearly crops of annual and perennial plants grown upon it. For every plant or animal living on the surface of the earth, there are hundreds of kinds of lower forms of life which lead their entire existence within the soil and which give life to the soil itself. These are the microscopic organisms commonly known as microbes, comprising numerous bacteria, molds, yeasts, and yeastlike forms, protozoa, minute worms, and many others. They belong to both the plant and animal kingdoms. They vary considerably in size, ranging from forms large enough to be seen with the naked eye to those that require very powerful microscopes in order to be detected. Their numbers are recorded not on the basis of an acre or even a pound of soil, but per 1 gram of soil, or a small fraction of a pound. The abundance of these organisms in different soils depends upon the nature of the soil, upon the methods of soil treatment and fertilization, nature of crops grown, and a number of other factors, such as reaction, temperature, aeration, moisture supply, and amount of organic matter.

Certain well-defined techniques have been developed for determining the numbers of the various micro-organisms inhabiting the soil and for measuring their activities. It has been established that these numbers vary from several millions to many billions per 1 gram of soil. Although even these large numbers make up in volume only a small part of the actual mass of the soil, they bring about numerous chemical transformations, as a result of which they influence in many ways the growth of the cultivated and uncultivated crops. They also exert certain important physical effects upon the soil. This is especially true of the binding effect upon the soil particles, either through the production of certain slimy substances or through their long and thin cell bodies. They are thus able to bring the soil into a better physical state, and prevent rapid removal of the soil by water. On the other hand, in the case of heavy soils, the various gases produced by these micro-organisms, notably the carbon dioxide, keep the soil in loose friable condition favorable to the cultivator and to the growth of the crop. The soil microbes also assimilate in their bodies large amounts of essential plant nutrients, notably the nitrogen, the phosphorus, and other elements, and thus prevent the rapid leaching out of these elements. The bodies of these micro-organisms later decompose and liberate the nutrients back into circulation; they serve, therefore, as storehouses of plant nutrients in the soil.

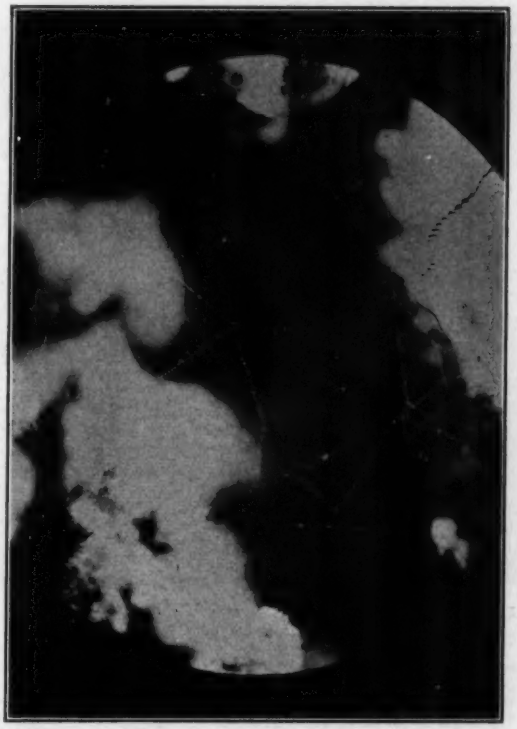

Figure 1.—Direct microscopic examination of soil, showing the growth of mold mycelium binding the soil particles.

THE mere listing of the names of the numerous micro-organisms found in normal soils would require considerable space; it is hardly necessary for the purpose of this discussion. It is sufficient simply to indicate that these microbes can be broadly classified into plant and animal forms. The plant forms are usually further subdivided into those

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Figure 2.—The growth of another soil organism, an actinomyces, throughout the soil mass, as shown directly by the microscope.

organisms which contain green coloring matter or chlorophyl, namely the blue-green and grass-green algae, and those organisms which do not contain any chlorophyl, namely the fungi and bacteria. The algae function in the soil in a manner similar to higher green plants; they are able to assimilate carbon dioxide and synthesize organic matter, the function of which in increasing the organic matter supply of the soil is still unknown. A few of the algae, found among the blue-green forms, are also capable of fixing atmospheric nitrogen; here as well, the importance of the process in increasing the supply of soil nitrogen is a matter for further study.

The nonchlorophyl bearing microbes have received the greatest attention, since they are the ones that are known to play the most important roles in the chemical soil processes. They bring about the disintegration of the plant stubble and leaves, farm and kitchen wastes, and numerous other plant and animal residues in the soil and in the compost. Gradually these materials are transformed into a dark-colored homogeneous mass known as humus, which imparts to the soil some of its important characteristic properties, and thus distinguishes a soil from a mere mass of fragments of disintegrated rock material. The essential elements stored in the residues are changed, in the process of decomposition, into forms in which they can again be utilized by the growing crop. The carbon is changed to carbon dioxide, the nitrogen to ammonia, the phosphorus to phosphate, etc. The relative proportions of the waste residues that become mineralized or that are changed into humus depend upon their nature and upon the conditions under which decomposition takes place.

In addition to the foregoing processes, these microbes bring about numerous other chemical changes in the soil which are essential for rendering the soil fertile and permitting the growth of a normal crop. Some bacteria are able to fix nitrogen, thus increasing the store of the combined nitrogen in the soil. Certain organisms are able to carry out this process independent of higher plants, that is in the soil itself, and are thus known as nonsymbiotic organisms; other bacteria fix atmospheric nitrogen only when they live within the root systems of certain higher plants, mostly belonging to the Leguminosae, and are thus known as symbiotic organisms. The exact mechanism of these two processes is still a matter for further study; they are of the greatest importance in soil fertility. Still other microbes are capable of oxidizing various elements or compounds in the soil, such as ammonia to nitrate, sulphur to sulphate, thus affecting the availability of these important elements for plant growth.

The animal population of the soil also comprises a great variety of forms ranging from the numerous microscopic protozoa to the large earthworms. The major function of these organisms consists in working over of the soil, mixing the organic and inorganic contituents, thus improving the physical texture of the soil. These animal forms also exert, through their activities, various effects upon the crop; these may be either beneficial or injurious in the economy of the soil. It is sufficient to mention, in addition to the physical effects, the ability of many animal forms, notably the protozoa, to decompose various plant and animal residues; they are thus able to function in a manner similar to the bacteria and the fungi. On the other hand, some forms attack the root systems of higher plants and produce various diseases, such as the

root galls and the root knots caused by nematodes. Various plant-destroying insects, such as the Japanese beetle and others, pass a part of their life cycle in the soil and may thus be considered as soil forms.

As a result of their activities in the soil, the microorganisms are responsible for numerous chemical changes which affect the growth of crops in many ways: 1. They take part, either directly or indirectly, in the processes of weathering and in the formation of the different soil types. 2. They reduce the tremendous waste of plant and animal life and transform these residues into humus, which becomes an essential and important part of the soil system and which exerts highly favorable effects upon crop growth. 3. They change the essential plant nutritive elements in the soil into a condition in which they can again be utilized by the crop. 4. They improve, directly or indirectly, the physical condition of the soil, so as to render it a favorable medium for the growth and nutrition of the root systems of higher plants. 5. They destroy various injurious substances formed in the soil, which would otherwise affect detrimentally the growth of the crops. 6. They antagonize and keep in a certain check the development of various injurious bacteria, fungi, and nematodes which would otherwise destroy the crops completely. These soil microbes may thus be truly considered as the greatest friends that man has on this earth. They form the true connecting link between the living and dead worlds, between the organic and inorganic worlds. Without them life would soon come to a standstill. It is as a result of their continuous activities that life of plants and animals is made possible on this planet, that waste products can again be transformed into living products of the plant and animal worlds.

Among the characteristics which distinguish a rich soil from a poor one, a fertile soil from an infertile one, are, primarily, the abundance of organic matter, the availability of the nutrient elements in the soil, and the activities of its microbiological population. The latter may thus be considered as a true index of the fertility state of the soil. One can easily measure, by certain laboratory procedures, the rate of availability of the nitrogen in the soil, of the phosphorus and the potassium, the rate of decomposition of the soil humus, etc.

In addition to the favorable organisms, however, the soil also harbors certain injurious microbes which cause different plant diseases, as in the case of the fungi that cause the damping-off of nursery stock and of numerous vegetable crops, of the scab disease of potatoes and sugar beets, of the take-all disease of cereal plants, of a great variety of root rots, root galls and other diseases.

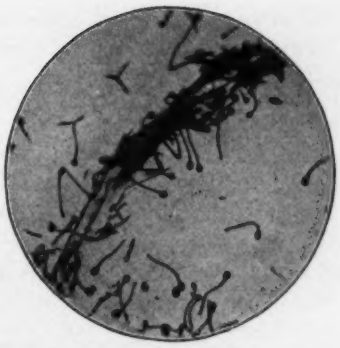


Figure 3.—Attachment of bacteria to a particle of organic matter which they are destroying. Highly magnified.

Certain disease-producing organisms of animals and man may also be harbored and even lead a normal existence in the soil. It is sufficient to mention the botulinus organism, the tetanus bacillus, the gas-gangrene producing bacteria, the organism that causes lumpy jaw of cattle, hookworm larvae and the larvae of numerous insects, in order to appreciate their possible significance. Although our present methods of control of these disease-producing organisms depend upon physical and chemical soil treatments, crop rotations, and selection of immune varieties, it is now becoming more and more recognized that these injurious organisms are largely kept in check in the soil through the activities of the normal soil microbes. The various common soil fungi and bacteria have been shown to be able to exert decided protective effects

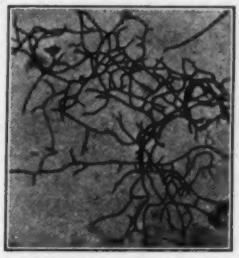


Figure 4.—Strands of a typical soil organism, an actinomyces, removed from the soil. Highly magnified.

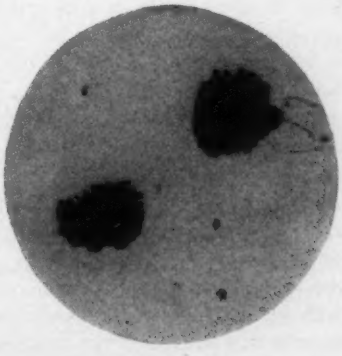


Figure 5.—The growth of bacteria in soil in the form of colonies, as determined by special methods. Highly magnified.

against the rapid spread of disease-producing organisms which would otherwise cause complete destruction of cultivated crops.

The question often arises whether it will ever become possible or advisable to introduce micro-organisms into the soil to hasten processes which are already taking place in the soil, to bring about new processes, or to help keep in check certain disease-forming organisms. One must state emphatically that, with certain very few exceptions, the introduction of beneficial organisms into the soil has not progressed beyond the use of legume cultures. While there is no doubt that a few organisms may at times be profitably introduced into the soil, either because of their absence in certain soil formations or because they may be present in a weakened state, as in the case of certain mycorrhiza fungi for forest nursery stock, the indiscriminate use of all-crop inoculants should be condemned. In most cases an improvement in the microbiological condition of the soil will follow the correction of the physical and chemical soil conditions, as upon the addition of lime to acid soils, of organic matter to depleted soils, upon proper aeration of poorly drained soils, etc. In the use of sulphur for the correction of alkalinity of the black-alkali soils or increasing the acidity of potato soil, to prevent scab development, certain specific bacteria were found to play an important role; whether the introduction of special cultures of these bacteria for inoculation purposes is justified or not, the fact remains that the oxidation of the sulphur is brought about largely through the action of these bacteria, the presence of which in soil is highly essential.

One may ask further, What role do all these micro-organisms play in the conservation of the fertility of the soil? What part do they play in preventing the losses of the soil itself? These losses are usually brought about in three distinct ways, namely as (1) gaseous losses, notably the soil nitrogen; (2) losses in a liquid state, through the constant dissolution of some of the plant nutrients by the movement of the water in the soil; and (3) losses in a solid state, or true soil erosion. It has been amply demonstrated that the problems of water and wind erosion, as well as soil deterioration due to improper systems of cultivation, are closely associated with the problem of soil organic matter. A decrease in the organic matter content accompanies soil deterioration and is in itself a cause for further deterioration, while an increase in organic matter and nitrogen is a symbol of soil improvement. Micro-organisms are closely associated both with the formation and with the destruction of the organic matter, and with an increase or a decrease of the available nitrogen. Any systems of permanent soil improvement or soil conservation must, therefore, consider the influence of soil treatment upon the activities of the soil-inhabiting micro-organisms, as well as the methods of utilizing their activities in order to bring about a permanent system of agriculture. One must further consider the fact that soil erosion results in the loss of the active or living surface layer of the soil, leaving the dead subsoil. The latter, because of lack of aeration and of sufficient nutrients, limits the growth of the important soil micro-organisms.

Another important soil phenomenon may be classed under the group of processes leading to soil deterioration, namely, the formation of sick or exhausted soils. In many cases, this is due to the accumulation of fungi, bacteria, protozoa, nematodes, and larvae parasitic either upon higher plants or upon the normal microbiological population. In other instances, it is due to the formation of toxic substances, the nature of which is not fully established, which are injurious to plant growth, in one way or another. Some of these deficiencies can be corrected by treatment of soil with steam or certain chemicals (partial sterilization); others are corrected by the introduction of specific mineral elements not commonly employed in fertilizer mixtures, such as copper, manganese, and zinc; still other conditions can be prevented or corrected by proper systems of crop rotation and soil improvement. One is dealing here with a group of important soil relationships, the nature of which is still incompletely understood, although considerable knowledge has already accumulated and various methods (palliative, to be true) have been developed for correcting the deficiencies. Soil conservation must keep a proper balance of the microbiological population of the soil and a proper state of microbiological efficiency. Attention may also be called here to the recent investigation on the phenomenon of soil fatigue caused by the accumulation of bacteriophage in old alfalfa and clover soils. This results in the destruction of the specific bacteria concerned in the formation of nodules, thus leading to reduced nitrogen fixation. The plants behave under these conditions as nonlegumes. Different plants and different varieties of the bacteria producing the nodules are not sensitive alike to the bacteriophage, which thus suggests methods for overcoming this soil condition.

In addition to preventing and combating soil losses, micro-organisms can also be made, with proper systems of crop rotation and soil management, to increase the fertility of the soil; they are thus able to replace at

least some of the nutrients lost from the soil. It is sufficient to mention here the use of stable manures, composts and green manures. These serve several distinct purposes in the soil: (1) They conserve the plant nutrients from being leached out; (2) they render the nitrogen available for the following crop; (3) they add organic matter to the soil; (4) they increase the supply of nitrogen in the soil through judicious utilization of leguminous crops.

The micro-organisms of the soil must be managed and their activities controlled; they must be domesticated, just as are cultivated crops and domestic animals. Although only very few microbes—such as the legume bacteria, certain sulphur bacteria, some mycorrhiza fungi, and some of the nitrifying bacteria—have so far been domesticated, the future holds forth promise of utilization of many other lower forms of life, and this will enable man to control at will the various soil processes which affect the growth of his crops and his animals. Only then will man take full advantage of the soil microbes as agents to help him in the conservation of the tremendous wealth that nature has stored in the soil. [2]

[2] Further information on the subject discussed in this article can be obtained from Dr. Waksman's book, Principles of Soil Microbiology, from which most of the accompanying illustrations are taken.

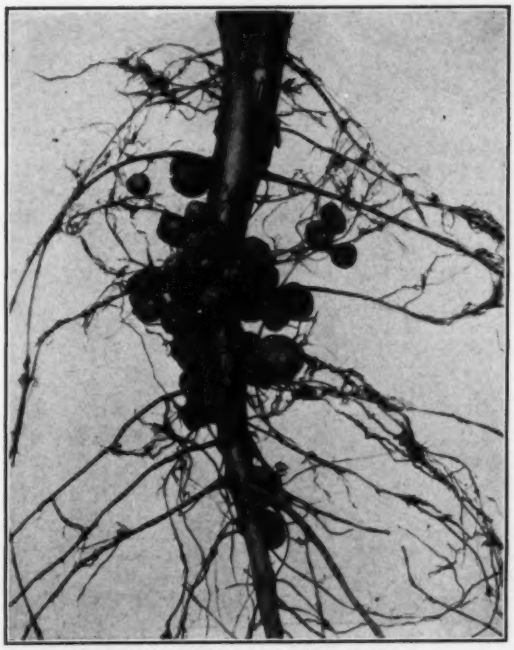


Figure 6.—Bacteria from nodules on the roots of a leguminous plant (soy bean).

620 MILES OF CONTOUR FURROWS

(*Continued from p. 172*)

position. Drawbacks of these methods were generally a nonuniform trench, requiring extensive hand finishing and excessive cost.

Solution of the problem came with the perfecting, on the project, of a contour-furrow builder that does the work of a hundred men. A heavy 22-inch brush-breaker plow, pulled by a track-type tractor, scoops out a 12-inch deep furrow. The machine has a special damming attachment, operated hydraulically from the seat of the tractor, which allows the furrows and dams to be completed in one trip. Dams, placed at intervals of 12 to 50 feet, prevent concentration of water at low places and result in a more even distribution of moisture, in addition to permitting slight deviations from the contour.

With contour furrows covering at the present time more than 2,000 acres of sloping land adjacent to Pocatello and aided in their water utilization work by extensive systems of waterspreading ditches emanating from gully dams, the next step consists of the planting of the disturbed earth to adapted grasses. Vigorous growths on these planting sites where moisture is plentiful have already proved their ability to spread and cover the areas between furrows. Necessary to the success of the revegetation program, grazing has been completely restricted from the area for the duration of the 5-year cooperative agreements.

Citizens of Pocatello realized, through annually recurring depositions of silt, sand, and debris following seasonal cloudbursts peculiar to the areas surrounding the city, the necessity of permanent control measures. Civic cooperation has done much to facilitate the work of the Service. Mindful of the harm that has been done through cutting of juniper stands for firewood, and destruction of the remaining forage by huge flocks of sheep on their way to high ranges and back to market, civic and county authorities virtually have turned the critical areas over to the Service. Control of the problem, to them, has meant property insurance.

Control is simple and straightforward. A series of level pockets catches the run-off from the slopes and hold it until it soaks into the ground. More vegetation grows where more moisture is available. More vegetation will check more runoff. Providing against the ever-existent flash-rain contingency, the contour furrows will continue their usefulness long after sufficient vegetation in the form of grass, shrubs, and trees has grown to pin down the soil and hold rain water.

Camp Bannock's tree-planting program has a threefold purpose: First, to stabilize the contour furrows;

(*Continued on p. 202*)

The Beaver as an Upstream Engineer

Sheep grazing on an ancient beaver meadow.

By Paul M. Scheffer [1]

FROM time immemorial the beaver has been America's number one conservationist. Even today he is a foremost wildlife citizen—and a decidedly useful one at that. His successful efforts in soil reclamation, reforestation, hydraulic and agricultural engineering, agronomy, and water conservation antedate the work of the Soil Conservation Service by more than a million years.

Many thousands of years before the landing of Columbus on the shores of this continent the beaver was doing his bit toward building the land for present-day agriculture. His dams in the streams created countless numbers of ponds over most of the United States and Canada. The waters were intentionally impounded to serve as protective moats for the beaver homes. The dams served also to stabilize the flow of the streams by reducing the force of the water and the crest of floods. The beaver was the original upstream engineer.

In the course of time the old beaver ponds were silted to the brim. Arable meadows were formed, and the succession of plant life which followed made the beaver the pioneer agronomist. Moreover, his work assisted the forester, as well. Many of the swamps created by the beaver grew up to dense stands of shimmering aspen, cottonwood, birch, and willow, and these deciduous lanes along the bottoms of the valleys proved effective in the protection of coniferous stands on the slopes above.

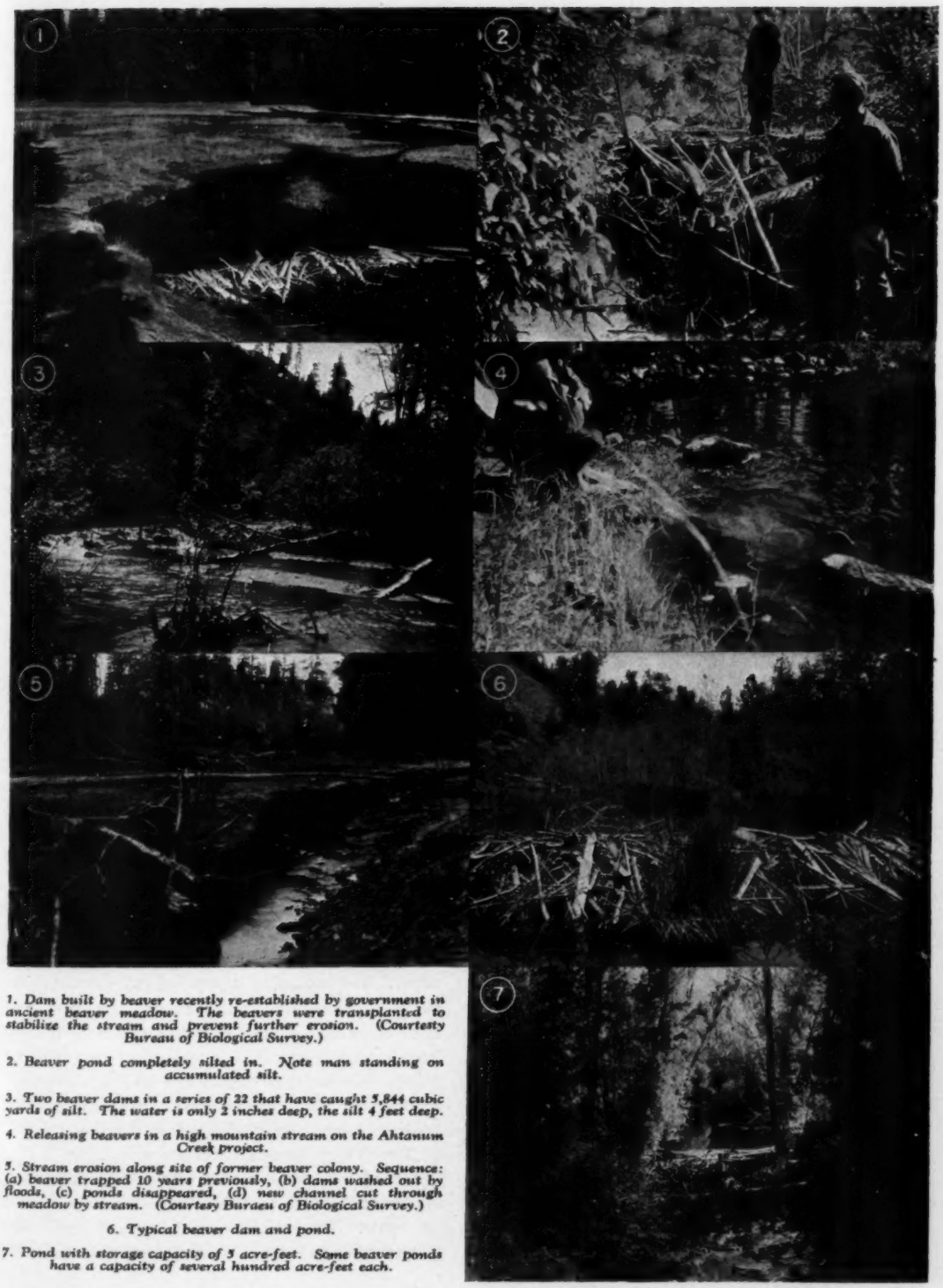
With the cycle of formation of fertile valleys and deciduous forests nearly complete, the old patriarchs and the young beavers moved to sites where the water ran unchecked. Here they built their homes and began the cycle anew.

This story is told to introduce the beaver, by way of giving the history of his importance in American agriculture. It also indicates why the beaver was enlisted as an ally of the Soil Conservation Service in its soil- and water-conservation program. Proof of the value of the beaver in a present-day program of this kind is easily obtained, as is attested by definite figures from recent investigations carried on by the wildlife management section of the Service.

The Mission Creek Camp near Cashmere, Wash., was established by the Service for flood-control work.

(*Continued on p. 180*)

[1] Junior biologist, Soil Conservation Service, Badger Pocket Area, Wash.



1. Dam built by beaver recently re-established by government in ancient beaver meadow. The beavers were transplanted to stabilize the stream and prevent further erosion. (Courtesy Bureau of Biological Survey.)

2. Beaver pond completely silted in. Note man standing on accumulated silt.

3. Two beaver dams in a series of 22 that have caught 5,844 cubic yards of silt. The water is only 2 inches deep, the silt 4 feet deep.

4. Releasing beavers in a high mountain stream on the Ahtanum Creek project.

5. Stream erosion along site of former beaver colony. Sequence: (a) beaver trapped 10 years previously, (b) dams washed out by floods, (c) ponds disappeared, (d) new channel cut through meadow by stream. (Courtesy Bureau of Biological Survey.)

6. Typical beaver dam and pond.

7. Pond with storage capacity of 3 acre-feet. Some beaver ponds have a capacity of several hundred acre-feet each.

(Continued from p. 178)

Overgrazing and logging had produced a situation in the upper drainage basin which allowed heavy run-off of water resulting in serious floods in the valley below. Many blocks of valuable orchard trees were washed out, and acres of other orchard land were covered with rocks, soil, and debris.

In 1935 it was discovered that a few beavers in the upper waters of Mission Creek were doing effective work in the control of soil and water losses. Through the Washington State Game Department, 12 more beavers were secured by the Service and added to the colony. These were vagrant beavers trapped from sloughs along the Wenatchee River, 20 miles away. In 1937 a survey was made to determine what work had been accomplished. It was found that where the beavers had formerly occupied only a few hundred feet of stream there were now approximately 60 dams in more than 5 miles of the waterway. Most of the ponds were silted full with the fine sandy soil of the area. At some points the stream bed had been widened from a few feet to more than a hundred feet.

One section of Mission Creek was chosen for a detailed study of the beaver work. This stretch was 2,040 feet long, with a total drop of 50 feet. It contained 22 beaver dams, averaging 42.86 feet in length and 2.84 feet in height—a total length of 943 feet and a total height of 62.6 feet. Five thousand eight hundred forty-four cubic yards of silt had been caught behind the dams; and during the low summer flow of the stream 1.44 acre-feet of water were being stored in the ponds. In the table may be found complete information on each dam.

Measurements of beaver dams, and erosion and flood-control value, in the lower 2,000 feet of the East Branch of Mission Creek

Number of dam	Distance downstream from first dam	Size of dam		Cubic yards of silt behind dam	Gallons of water stored behind dams
		Length	Height		
	Feet	*Feet*	*Feet*	*Cubic yards*	*Gallons*
1	0	15	2	205.5	.....
2	70	16	2	62.5	.....
3	193	60	3.5	439.6	.....
4	323	15	1	72.5	.....
5	475	12	1.5	44.4	.....
6	516	25	3.5	57.5	.....
7	605	52	5	408.7	.....
8	637	32	3.5	706.6	.....
9	920	30	4	185.2	.....
10	1,030	28	3.5	169.1	.....
11	1,120	27	4.6	205	.....
12	1,200	55	4	392.8	.....
13	1,316	67	4.5	76.7	.....
14	1,403	33	3	255	.....
15	1,435	28	1	48.3	.....
16	1,450	25	1	20.3	.....
17	1,573	110	2	694.5	.....
18	1,650	90	3	455.6	.....
19	1,735	120	1	291.2	.....
20	1,780	68	2	173.3	.....
21	1,835	18	3	40.8	.....
22	2,040	8	4	121.6	.....
Total	2,040	943	62.6	5,844.2	[1] 471,675

[1] 1.44 acre-feet.

In 1935 the Service established a camp in the Ahtanum Creek drainage basin near Yakima, Wash., for the purpose of demonstrating water conservation work on about 45,000 acres of land.

The water of Ahtanum Creek is used to irrigate a large agricultural area west of Yakima. Typical of all mountain streams, the Ahtanum varies in its flow with the seasons of the year. During the spring run-off, the stream reaches near-flood proportions and occasionally causes damage. A good flow of water is maintained until July after which the flow rapidly decreases. Through the latter part of July, and in August and September, there is not sufficient water in the stream for irrigation purposes and the crops suffer accordingly.

In order to remedy this condition the Service, besides putting into effect a well-managed grazing and forestry program, has constructed at great expense several large water-impounding dams on the small intermittent side drainages of Ahtanum Creek. These ponds fill up during the heavy spring run-off and store thousands of gallons of water that would otherwise be lost. Later in the summer when the water is needed in the valley below, the ponds slowly drain into the streams.

With the conviction that beavers could be of material assistance in the program the Service in 1936 obtained 10 of the animals from the Washington State Game Department and transplanted them from the irrigation ditches of the lower Yakima Valley orchard district to the Ahtanum Creek area, 60 miles away. In their new homes on the project the beavers constructed several large dams, one of which in particular is worthy of note in that it is doing effective work in the storage of water in the upper drainage area. In June 1937 the dam was 90 feet long, 7 feet high, and was blocking a stream flowing 65 second-feet of water. The storage capacity behind the dam was 691,500 gallons or 2.11 acre-feet. The dam was again observed 3 months later and was found to have been extended several rods and raised an additional 3 feet. The water storage at this time was estimated to be 5 acre-feet. Our engineers tell us that a man-made dam similar to the one just described would cost $2,500. The beaver dam cost almost nothing.

Encouraged by the success of the 1936 planting, a survey to appraise facilities for beavers was made a year later. The availability of the principal food trees (aspen, cottonwood, and willow) along all streams was

determined. The potential number of beavers that the streams could support was then worked out and a transplanting program was planned. The program planned calls for the moving of 50 to 60 beavers into the area within 3 years.

In the fall of 1937, 22 beavers were trapped from irrigation ditches near Cle Elum, Wash., where they had been causing the farmers considerable trouble by blocking irrigation systems and flooding fields. The beavers were taken to the Ahtanum Creek camp 100 miles away and turned loose at various sites selected in the headwaters of the area. As far as can be determined at the time all of the transplanted beavers are in the vicinity of the original planting sites, and they have started construction work on several dams.

It is interesting here to point out the low cost of water storage by beavers: It is estimated that within a 10-year period after the completion of the beaver transplanting program in this Ahtanum Creek area costing $500, the beavers will have constructed enough ponds to have a total water-storage capacity of 500 acre-feet, or $1 per acre-foot. And this is only a beginning as far as the beavers are concerned.

It is not implied here that beaver transplanting and management should supplant other programs designed to conserve soil and water on the Ahtanum Creek camp, Mission Creek camp, or any other area. It is suggested, however, that on those projects where stream stabilization is necessary for soil and water conservation, a program in which beavers are utilized to supplement other control measures should be initiated. If this is done, more efficient and certainly less costly results will be obtained.

Much work is yet to be done before the management of beavers can be completely successful. The biggest problem is the working out of methods to induce the animals to remain at the transplanting sites and to prevent them from wandering off to plug up some irrigation system or cut down choice apple trees. However, if the proposed planting sites are carefully studied and planned, the transplanting of beavers should be as simple and satisfactory as the moving of fish from one stream to another.

Thus we see that proper management of the beaver—original upstream engineer, agronomist, and forester—will make available to us many benefits in effective soil and water conservation. We are indebted to the beaver for what he has done; let us give him every opportunity to continue his work.

Seeding Mixtures

In examining the results obtained from the use of recommended seeding mixtures of commercial grasses and legumes on numerous projects throughout the country, I have concluded that the matter of mixtures is still an open question. I am of the opinion that in many cases such mixtures are not the result of actual experimental work but that they have been built up theoretically. I recommend that the agronomists on the projects and in the camps make an attempt to study the results obtained from seeding mixtures and use this information, after contacting the State experiment stations, as the basis of future recommendations. Such observations should be made carefully, as often the failure of any particular grass or legume may be due to poor seed or poor seeding conditions.—C. R. E.

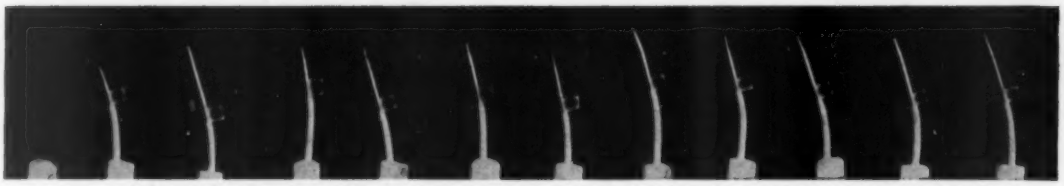
Domestic Ryegrass

Domestic ryegrass occupies extensive areas of poorly drained land in the Willamette River Valley of western Oregon. These areas are harvested for seed, and sometimes sufficient seed remains on the land to reseed it.

This grass offers excellent fall, spring, and even winter grazing on rather poorly drained soils in our Southern States. In many localities, such as Oklahoma, the livestock can be removed from the grass in time to allow it to reseed. There are many thousands of acres of such lands now lying idle which might be utilized for pasture, thus relieving the burden on other pastures or allowing badly eroded grasslands to be retired to woods.—C. R. E.

Terrace Outlets and Meadow Strips

Throughout the soil conservation projects, there has been a distinct tendency, during the past year or more, to locate terrace outlets in natural depressions rather than to construct these outlets artificially. This tendency should be encouraged, as natural depressions are much more satisfactory for the production of vegetation. Certainly, artificially constructed terrace outlets or meadow strips should be given a very liberal application of manure and commercial fertilizer if vigorous vegetative growth is to be expected. Frequently it is necessary to establish meadow strips or terrace outlets hurriedly in order to take care of the water from the terraces. A mulch of manure or other material, spread over the seeding, will invariably assist in securing a better stand and heavier growth. In critical locations, the mulch can be tied down with chicken wire. Certainly, such a method of establishing grass is much more economical than sodding, and farmers are willing to employ such practices. Usually farmers cannot afford to sod waterways or terrace outlets.—C. R. E.



Curvature of oat coleoptile following application of agar block containing 4.10^{-7} mg. of indole-3-acetic acid.

Curvature of oat coleoptile following application of agar block containing 8.10^{-7} mg. of indole-3-acetic acid (heteroauxin). (After Van Overbeek.)

Synthetic Growth Substances, a New Development

By V. T. Stoutemyer [1]

ONE of the serious obstacles in the production in large quantities of the most desirable plants for soil conservation purposes is the much greater expense and difficulty of vegetation propagation as compared with the starting of plants from seed. The advantage of securing products of economic value from plants used to check erosion needs no emphasis. The use of superior varieties or selected plant strains is highly beneficial in many instances, to improve both the erosion control and the economic qualities of these plants, and this necessitates vegetative propagation. Unfortunately, vegetative methods often are too costly for production on a large scale, and the use of seedlings is the only alternative. In the field of forestry the same difficulty has discouraged hybridization and selection of superior varieties of forest trees, except with a few kinds such as the poplars which may be propagated very easily by means of hardwood cuttings. The shipmast locust [2 3 4 5] is an example of clearly demonstrable superiority of a selected variety over seedlings. Many other similar illustrations could be cited, pointing out plants of all kinds.

IT is hoped that the recent developments in the use of plant hormones or synthetic growth substances will assist in solving this problem. Any predictions as to the extent to which these materials may be adapted in the future, or the value they will have in propagating exceptionally difficult subjects, are quite unsafe. The new technique in propagation is now being employed, however, by practical propagators in commercial greenhouse and nursery establishments.

From a purely scientific point of view, the recent discoveries regarding growth substances in plants constitute an exceedingly important development in the field of plant physiology. Although the subject has come into prominence only recently, it is not entirely new; the existence of plant hormones was suggested on a largely speculative basis, by the botanist Sachs as long ago as 1882. Most of the early knowledge of plant hormones was developed during the earlier part of the present century by a number of European botanists, including Fitting, Boysen Jensen, Paal, Söding, and Went. Only recently experimentation was started by a few American research centers, notably the Boyce Thompson Institute for Plant Research, the California Institute of Technology and the Division of Fruit and Vegetable Crops and Diseases of the Bureau of Plant Industry of the United States Department of Agriculture. Some of the greatest advances have been made at these institutions.

As a basis for the study of plant hormones, almost all of the early workers concentrated on the end of a shoot

[1] Assistant Horticulturist, U. S. Plant Introduction Garden, Bureau of Plant Industry, U. S. Department of Agriculture, Glen Dale, Md.

[2] Morrison, B. Y. A new variety of black locust. Science 82: 326-327. 1935.

[3] Raber, O. Shipmast locust, a valuable undescribed variety of *Robinia pseudoacacia*. U. S. Dept. Agr. Circ. 379. 1936.

[4] Detwiler, S. B. The history of shipmast locust. Journal of Forestry 35: 709-712. 1937.

[5] Hall, R. C. Growth and yield in shipmast locust on Long Island and its relative resistance to locust borer injury. Journal of Forestry 35: 721-727. 1937.

(coleoptile) of a young oat seedling grown in the dark. Even now, the oat plant, *Avena sativa*, is much used for detecting the presence and estimating the activity of small quantities of plant hormones. This large use of a standard subject for experimentation is very fortunate as it enables workers in all parts of the world to compare results.

The response of the coleoptile to light was the first reaction studied. The coleoptile of a young oat plant which has been grown in the dark will bend toward the light upon exposure. The curvature is caused by the action of a plant hormone formed at the tip which stimulates growth on one side of the coleoptile. Agar blocks containing minute quantities of the hormone, placed on the coleoptile, will cause the same responses, even if the tip is removed. Similar effects may be obtained by the use of a number of chemicals prepared synthetically or extracted from certain plant and animal products. The degree of curvature in the coleoptile is related to the amount of hormone present, which makes possible one of the methods of quantitative determination. The relative curvatures of oat colepotiles caused by two different concentrations of indole-3-acetic acid (heteroauxin) are shown in figures 1–a and 1–b.

An important advance was made when European chemists including Kögl, Haagen, Smit, and Erxleben showed the composition and structure of those substances extracted from urine and from various animal and plant products which caused the typical hormone-like responses on the oat coleoptile. The rapid development which occurred is summarized in Boysen Jensen's [6] book which appeared in an American edition in 1936.

[6] Boysen Jensen, P. Growth hormones in plants. Authorized translation and edition by G. S. Avery, Jr., P. R. Burkholder, H. B. Creighton, and B. A. Scheer. New York. 1936.

Lemon cuttings treated at the base with tap water for 8 hours. Root development after 2½ weeks.

Lemon cuttings treated at the base with heteroauxin (0.5 mg. per cc. of water) for 8 hours. Root development after 2½ weeks. (After Cooper.)

Hormones have been shown to play a definite role in many of the life processes of plants, beginning with seeds, where they apparently play a part in germination and the growth of the seedling. They are essential for the shoot growth of higher plants and they regulate cell division and enlargement, although in a manner not understood at present. They may start bud growth or cambial activity, but they can also inhibit growth in other places in a plant simultaneously. Phytohormones may start the formation of tumors and intumescences on plants and initiate the production of roots on stems. It is known also that these substances control some of the movements of plants in response to light and gravitation. Hormones are probably connected with the process of seed production in plants, and already the existence of substances which cause flowering in certain plants has been claimed. The application of some of the synthetic growth substances to flowers has caused the production of parthenocarpic fruit, or in other words, fruit which has been produced without fertilization and which does not contain viable seed.

The spectacular aspects of the subject have furnished welcome material to writers for the newspapers and popular magazines. Some of this publicity has been regretted by serious scientists. In some instances, worthless materials have been sold to the public as root forming hormones.

While the nomenclature of the subject is still unstandardized, all authors try to draw a distinction between the hormones which are believed to exist in living plants and the numerous synthetic chemicals which cause similar hormone-like responses in plants. The latter group of substances is designated by terms such as growth promoting substances, synthetic growth substances, or root forming substances. They cannot properly be called plant hormones.

Which are the true hormones? This is not known definitely, although three substances of known composition have been suggested as occurring in higher plants. These are:

Auxin a ($C_{18}H_{32}O_5$) Auxentriolic acid
Auxin b ($C_{18}H_{30}O_4$) Auxenolonic acid
Heteroauxin ($C_{10}H_9O_2N$) Indole-3-acetic acid

These three substances have been found in fungi; and although they have been reported to occur in higher plants, this has been contradicted. The exceedingly minute quantities of hormones present in plants make chemical determinations a difficult problem, even though their high potency allows a quite simple demonstration of their presence. Both auxin a and heteroauxin may be obtained from human urine. Heteroauxin may be extracted from certain molds and yeasts. Auxin b has been prepared from plant oils and malt.

Growth promoting substances at present have practical applications as aids to root formation in stem cuttings of plants. The reports of several investigators in recent years have suggested that root formation in cuttings is initiated by a hormone present in the buds and leaves of plants. This was designated by Bouillenne and Went [7] as "rhizocaline." Workers at the Boyce Thompson Institute for Plant Research [8 9 10 11 12] made the important discovery that identical responses in root formation could be secured by using various gases, organic acids, and esters. They have now discovered approximately 50 compounds which will initiate root formation on stems. The mechanism by which exceedingly minute quantities of these compounds cause root formation on stems is not known. Indolebutyric acid, indoleacetic acid, phenylacetic acid, indolepropionic acid and napthaleneacetic acid are the compounds which have been most commonly used for root stimulation. Indolebutyric acid has proved especially effective with a wide variety of plants. These substances are crystalline compounds and are used in very dilute aqueous solutions. The crystals are first dissolved in a small quantity of alcohol and the water is then added to give the required dilution. No general rules may be given for the amount of dilution since the most favorable concentrations vary with the particular species of plant. As a rule, the solutions vary from 20 to 50 milligrams per liter of water. Even lower concentrations are used for succulent herbaceous cuttings, while the higher concentrations are needed for a more woody type of cutting. The time of treatment varies with the different species and may vary from an hour to three days. As a rule, the woody plants require the longer treatments. Overtreatments, by using either a too strong solution or for too long a time, is quite injurious to the cuttings. Some information for the treatment of different species of plants is now available, but much more experimental work will be necessary to determine the best treatments for different plants.

The treatments are applied by making the cuttings in the conventional way and then placing the cut basal ends in containers of the solution in such manner that the transpiration of the cuttings will cause the solution to be taken up. The cuttings are treated under ordinary room conditions. The full light of the sun should be kept from the cuttings during treatment. At the end of the time required for the particular species of plant, the cuttings are removed and the solution is washed from their bases. The cuttings are placed in the ordinary propagating structures and care is given exactly as with ordinary untreated cuttings. An illustration of the effectiveness of these substances in stimulating rapid root formation is shown in figure 2.

This illustration shows the quick and abundant root formation in lemon cuttings following treatment with heteroauxin in an experiment by Cooper.[13] A clue to the manner in which growth substances act to induce root formation is given in the same report. Cooper's results indicated that the substance acts indirectly by causing the rapid movement of "rhizocaline" from the buds and leaves at the top of the cutting to the base. When the lower ends of the stems of treated cuttings were cut off, little stimulation occurred. This supported the theory that the removal of the lower ends of the cuttings also removed the accumulated rhizocaline at the base. After this was done, further treatment of the cutting with a solution of growth substance presumably was futile since the rhizocaline in the cutting was depleted.

Undue enthusiasm concerning the value of the growth

(*Continued on p. 189*)

[7] Bouillenne, R., and F. Went. Recherches expérimentales sur la néoformation des racines dans les plantules et les boutures des plantes supérieures (Substances formatrices des racines). Ann. Jard. Bot. Buitenzorg 43: 25–202. 1933.

[8] Zimmerman, P. W., and A. E. Hitchcock. Initiation and stimulation of adventitious roots caused by unsaturated hydrocarbon gases. Contrib. Boyce Thompson Inst. Plant Res. 5: 351–369. 1933.

[9] Zimmerman, P. W., and F. Wilcoxon. Several chemical growth substances which cause initiation of roots and other responses in plants. Contrib. Boyce Thompson Inst. Plant Res. 7: 209–229. 1935.

[10] Zimmerman, P. W., and A. E. Hitchcock. The response of roots to "root-forming" substances. Contrib. Boyce Thompson Inst. Plant Res. 7: 439–445. 1935.

[11] Hitchcock, A. E., and P. W. Zimmerman. Effect of growth substances on the rooting response of cuttings. Contrib. Boyce Thompson Inst. Plant Res. 8: 63–79 1936.

[12] Zimmerman, P. W., A. E. Hitchcock, and F. Wilcoxon. Several esters as plant harmones. Contrib. Boyce Thompson Inst. Plant Res. 8: 105–112. 1936.

[13] Cooper, W. C. Transport of root-forming hormone in woody cuttings. Plant Phys. 11: 779–793. 1936.

Agronomic Briefs

By C. R. Enlow [1]

Crop Rotations

This is a subject that should be given very serious consideration. How did our present rotations originate, and are they adequate to improve organic matter in the soil? Is it not true that rotations in general have been made to fit a scheme whereby farmers can continue to produce cash crops or crops of immediate cash return? Ordinarily, legumes are recommended in crop rotation systems mainly because an immediate increase in yields of cash crops may be expected.

What about grass in the rotation? Isn't it true, also, that a large supply of carbonaceous material in the soil is necessary actually to increase the organic content to such an extent and in such a way that it will remain there for a considerable period?

During a recent trip through France, I observed that most French farmers are following a rotation of root crops, small grain, and legumes, on approximately half of the farm while the other half is in permanent grass or legume-grass hay, or in pasture. After several years, the grassland is plowed for cropping while the cropped portion of the farm is seeded to grass. This system, coupled with proper management of grassland, the use of lime and phosphate, and the addition of manure, has resulted in a very high acre yield.

On soils very low in organic matter, the addition of a large quantity of carbonaceous material, such as grass, straw, or weeds, frequently reduces the crop yield for the next year. The reason for this is that the bacteria are using up available nitrates in the soil in breaking down the straw. It appears that if we are to use good judgment, such a program should be followed, with modifications, in this country, so that eventually we may achieve some actual improvement in the organic content of the soil and make it more productive. Legume-grass mixtures are perhaps the solution to the immediate problem, and it is recommended here that these be used wherever possible instead of straight legume seedings.

Contour Furrows

The use of contour furrows is justified by (1) the conservation of moisture to obtain a better vegetative cover, and (2) immediate erosion control necessary to ensure sufficient stabilization of the soil so that vegetation may come back naturally or from seeding. Moisture conservation is the primary objective in semiarid regions, while immediate erosion control is the main object in regions of higher rainfall. Furrows should be so arranged that considerable water will be held on the land in a form to be utilized by a large percentage of the vegetation. Certainly, if the grass is managed in such a way that the roots penetrate deeply into the soil and the cover of leaves and stems protects the soil from high temperature, evaporation will be reduced and the extra moisture will be of value during periods of drought.

Strip Cropping

Strip cropping in many modified forms is now covering approximately 1,000,000 acres in this country. There have been so many deviations from the general plan, principally to meet the farmers' objections, that it is doubtful in some cases if any worth-while results will be secured. Frequently, the strips have been made much too wide to secure erosion control. In other instances, strip cropping has been relied on for the control of erosion where it is very evident that both terraces and strip cropping should be employed.

Permanent grass or grass-legume buffers should be tried in many sections of the country where to date strip cropping consists largely of alternate strips of row crops and small grains. Deviations in strip cropping should be made in order that we may learn from actual results the type that should be recommended in any particular locality. Such deviations, should be based on the assumption that any change made will actually improve the chances for erosion control.

Establishment of Native Grasses

If our attempts in reseeding the native grasses of the drier regions are to be successful, we must keep in mind the importance of the fundamentals of such seeding. These are (1) a firm, almost solid seedbed; (2) proper depth of planting; (3) proper time of planting; (4) a mulch cover. The first three are generally known but in the past very little attempt has been made to provide a cover that will retain the moisture for a sufficient time to allow the seed to germinate. Possibly wheat stubble, weeds, Russian thistles, and other materials already on the land could be utilized. If, for instance, the seed is planted in a stubblefield and covered by running a cultipacker over it, much better results from the germination of small grass seeds may be expected than that from a very clean seedbed. This is particularly true where moisture is a limiting factor. Most of our native grasses are sufficiently hardy to live through the winter if they can be seeded in late summer when moisture is plentiful. If this cannot be done, late winter or very early spring seeding is recommended.

[1] In Charge, Agronomic and Range Management Section, Soil Conservation Service, Washington, D. C.

BLOTTERS INSTEAD

by Wellington
Editor ..... SOIL CONSERV

IT'S Nature's way in Minnesota.

It's bluegrass sod, and grassed waterways, and willow cuttings.

It's legumes, and small grains—in strips.

It's blotters instead of shingles.

Of Minnesota's soil-conservation projects, I visited four out of four. I talked with farmers. I attended staff meetings at night. From Garvin Heights, 575 feet above the town of Winona, I looked down upon the Mississippi Valley in panorama, with Lake Winona in panorama.

Yes, and wriggled through barbwire fences—re-threaded on contour—to examine new tricks in water-channel stabilization . . . groped down into a gully, its hoof-punched pockmarks obliterated by knee-high grass and a jungle tangle of young locusts . . . swapped yarns with "Lefty" Hymes, newspaper man anxious to "get going" under the new State soil conservation districts law.

I came in from a tour of the Deer and Bear Creek watershed, bearing samples of half a dozen different silt loams on parts of my anatomy, brought back to Faribault traces of the Carrington loam and silt loam for which the Prairie Creek drainage area is noted, nosed briefly into the Tama and Fayette soils of the Beaver Creek project at Caledonia.

For one solid week I dwelt midst the land and language of legumes, rotations, soil horizons, sheet washing, filter strips, bird-food patches, farm records, and taxation studies. By the end of that week I knew that Nature's way is Minnesota's way, that vegetation is both the theme and the reliance in cooperative erosion control on all four water-shed projects.

Take alfalfa, for example. Grimm, Baltic, Hardigan, in particular. In Minnesota U's Special Bulletin 104—

Badly eroded slope, John Bergler farm, where cow paths led to gullies. It is in the early spring of 1937; the snow in the ditches is 6 to 7 feet deep.

The same slope, May 1937, after smoothing and prepared for planting of sweet clover and black locust.

"Mike Redig brings his odd rows to the center."

In this view on the Vic Papenfuss farm, the shrubs in the immediate foreground are shrubs constituting part of a windbreak. They are followed, in order, by oats, corn, oats; across the draw the strips are oats, alfalfa, oats, and corn, oats, corn.

TEAD OF SHINGLES

Vellington Brink

..... SOIL CONSERVATION

worthy example of the editorial art—we are told that alfalfa is an A–1 soil-builder, a cheap source of protein for livestock, a grand hay yielder; dependable, adaptable, ideal in rotation.

DOWN at Spring Valley is visual confirmation. I found there that on 92 project farms alfalfa has tripled its acreage in 2 years! In the same span of time these farmers have also materially increased their permanent pasturage, added protection to their woodlots.

In the Deer and Bear Creek watershed the topography confounds by variety, ranging from almost level to hilly, steep, and rough. Control of sheet washing is by contour tillage, terracing, and strip cropping. Sharper slopes are going into hay, pastures, and trees. Rough, stony tracts are being taken from the plow and given over to hardwoods and conifers.

Specially in favor as soil safety-pins are caragana, buffalo berry, dogwood seedlings, cuttings of willow and cottonwood. Of proved merit here are white pine, Norway pine, jack pine, Scotch pine, ponderosa pine, Austrian pine, white spruce, Black Hills spruce, Norway spruce, red cedar, white oak, red oak, burr oak, pin oak, shagbark hickory, black walnut, hackberry, butternut, hard maple, soft maple, green ash, basswood, honey locust, and black locust.

The rapidly shifting conditions at Spring Valley, the two types of soil—forested and prairie—the wide assortment of slopes and characteristics, produce a kaleidoscopic picture of erosion control. Latest check-up revealed 114 cooperators in the official soil-conservation program, 13 other farmers seeking and receiving technical assistance and supervision, more than 4,000 acres strip cropped.

August—and stabilization. The wooded area above is given protection.

Wired-down sod flume draining 7 acres on farm of George W. Hazelton, near Racine, Minn. It replaces a gully which was 9 feet deep and 8 or 10 feet wide.

Diversion ditch in Winona County, fenced, sodded and planted to trees.

Strip cropping in Spring Valley. Observe the sodded draw between corn and grain strips.

A few random segments of the kaleidoscope:

A roadside farm notable as a notoriously "bad example." Erosion made it a bad risk for the Federal Land Bank. Eventually it sold for $20 per acre—just $20 per acre too much. It is the only abandoned farm in the area.

A 300-acre slope which until recently dumped its surplus waters into a creeping gully. Until C. C. C. labor did some intelligent filling, you would have crossed the gully on a bridge. Today the bridge is out and dirt is in. The draw below is taking care of an estimated discharge of 14 cubic feet of water per second, using a series of inverted chickenwire baskets in the channel and bluegrass sod on the rims. Of course, there is the inevitable barrier of barb-wire round about, enforcing a just-right ukase on grazing. Project Manager Jackson holds that properly grazed sodding is better than ungrazed.

A noteworthy departure in the form of a sodded draw with grass poking up through a mesh of wire spread to keep out woodchucks and gophers.

The Charles Steffins place with a road ditch sodded and farmed, with a masonry dam and rock apron—the rocks "puttied" in to circumvent damage by frost action. (If the job were to be done over, sod would substitute.) Farther down this same newly disciplined draw is a series of sodded humps. The farmer, of his own accord, taking his cue from numerous examples on nearby farms planted willows between. (This frequent apeing of demonstrated practices is known in shop jargon as "spread of practices"—a trend that serves to point the worth of project demonstrations.)

THEY dredged Lake Winona, fed by Gilmore Creek, a score of years ago—scooped it to a depth of 35 to 40 feet. Farmers skinned the hillsides of some of their most fertile soil—sent it down by slow freight to silt up the basin so painstakingly hollowed.

Herb Flueck, State coordinator, curved an eloquent thumb toward a brindle cow complacently browsing weeds far out from shore as he talked to me of the problem of soil losses in the area. "If erosion can be controlled here, it can be controlled anywhere."

Yet, even here on this exceedingly angular countryside, the raindrops and the soil particles are being securely tethered.

Witness the William Bergler farm.

Witness the Mike Redig farm.

Witness the Vic Papenfuss farm.

Witness the Louis Thill farm.

Witness the Henry Wessel farm.

It's a compact, narrow-breasted valley. Many a field lies partly within, partly without, the project boundaries. Many a farm began its transformation, therefore, on an experimental, tentative, trial basis. Many an operator had an unusual opportunity to adopt horizontal cultivation, contour strip cropping, restricted grazing, managed woodland, gully healing, on a part of his holdings while continuing his outmoded practices on the remainder.

And many an operator, as a result of checking and comparison, subsequently sought advice and assistance in extending modern soil conservation to every inch of his ground.

Wessel is the biggest farmer thereabouts. Wessel, fall plowing, whoaed his four mules, expressed his liking for the economy of transverse farming, told me, "I'd never go back." His land, greatly impoverished under "orthodox" farming in the past, is today entirely in strips—some of these bands containing as much as 12 to 18 acres each.

Other farmers of superior natural aptitude are, like Wessel, becoming better farmers. Quick to embrace improved methods, they are also alert to adopt new quirks that serve to make these methods still more efficacious. Strip cropping, for instance. Strip after strip in the Gilmore Creek area runs with both sides on the contour.

Redig, for instance, starts planting his potatoes and his corn at the outer edges of his strips, brings his odd rows to the center. He says that this system facilitates harvesting and cultivation, and further reduces water losses.

Brush dams, accompanied by strip cropping and rotations, are the usual restoratives for gully-gouged fields on the leaning walls of this watershed. One such field, one such gully, tells a story that is a repetition of innumerable stories. For years this field had been in corn. The slope, the drainage, the whole "lie of the land," spoke eloquently against the formation of gullies—and yet here was this gaping gash 2 to 4 feet deep, and growing alarmingly with every rain. Something had to be done, effectively and immediately. It could have been expensive masonry, but what it actually was, was bundles of small brush—butts uphill—supported by straw, wired and staked in place. The expedient was so simple, so inexpensive, so convenient as to be within scope of any farmer. At the time I saw this gully, it didn't look like much of a gully, after all. The farm's junior and silent partner, Nature herself, was doing a neat job of filling. The gully was hardly half its former size, and getting smaller with every big washer. Next season it will be "business as usual"—or better than usual—on this field, with mule and implements proceeding back and forth across the ditch without pause or hindrance.

Near Caledonia I saw beautifully laid-out single strips ribboning along the hillsides a full mile in length. This, too, is a land of broad-base Mangum terraces, of diversion dikes skirting the heads of gullies, of sodded waterways, of hitherto valueless farm groves now become revenue producers. Complete treatment is accorded each farm unit, according to its own peculiar set of requirements. And the running story of this treatment, as chronicled in printed signs along

the highways, takes one almost all the way from A to Izzard in the known lore of erosion control.

FORTUNATELY, on the Prairie Creek project, Faribault—fourth of the four Minnesota phalanxes of attack—prevention is the cure. Slopes are slighter, and erosion has been slower getting started. In this section of dairying and general farming, an alert husbandry today has an opportunity to stave off the tragedy of soil despoliation. Major attention is on organic reserves and rebuilding, on rotations and strip cropping, on switches from cultivation to grass. And among the erosion-combatting grasses, reed canary ranks pretty close to No. 1 where the land is low, hummocky, and peaty. Of this grass, says another of the excellent University of Minnesota series, Bulletin 137:

"No other forage crop, seed of which is available in quantity, will thrive so well on highly productive lands that are too wet for most other crops. On such lands, which would otherwise bring low returns or none at all, reed canary has yielded hay and pasture as valuable as, or more valuable than, the crops from equal areas of adjoining well-drained soils. It may be left undisturbed for several years and thus the best returns are obtained from the investment in seed."

But there is more than strip cropping and brush dams in the Gilmore Creek community. There are electric fences, hemming in lush stands of timothy, clover, redtop mixtures. There is winter wheat for cover. There are sod flumes, stabilized diversion ditches, fences replaced upon the contour as guides to the new farming system. There are woodlots managed for permanent income, and food-producing cover for wildlife. There are uses of vegetative materials that would constitute news to any agricultural engineer of the old school.

CONSPICUOUS in the "spread of practices" category is a large wealthy estate just outside the Beaver Creek project area, Caledonia. The manager induced several of the Soil Conservation Service specialists to contribute advice and supervision on Saturday afternoons and Sundays. He mantled the farm with contour-stripped vegetation. He broadcast in a descriptive booklet, "This farm is completely under erosion control."

Pastures are in prime popularity among farmers of this watershed. Every cooperator has at least one fenced-out woodlot; 80 acres in one typical 320-acre unit are so segregated. Abetted by the Service, one owner, whose only alternative was the construction of a masonry dam, ingeniously—and economically—devised a fence-protected stock pond which took safe and profitable care of the run-off from a grassed watershed of from 8 to 10 acres.

SPRING Valley, Winona, Caledonia, Faribault. Four representative watersheds: Deer and Bear Creeks, Gilmore Creek, Beaver Creek, Prairie Creek.

Deep fall painting the Minnesota valleys in the hues favored by butternut, walnut, maple, sumac, ivy, and oak.

Swift, cold streams where the sportive trout wait on a lightening of silt load.

Lights blazoning from the windows of rural homes where farmers again tally their books with black ink instead of red.

Cows milked, horses bedded down, barns locked.

Soils made secure, not only for tonight but for tomorrow.

SYNTHETIC GROWTH SUBSTANCES

(*Continued from p. 184*)

substances in practical use is possible. They are in no sense a panacea, and there are still many problems in propagation which they have not solved. With a few exceptions, such as the grape, hardwood cuttings have not responded to treatment, possibly because a good method has not been devised. Different varieties of the same species of plant may react quite differently. Thus, softwood cuttings of certain apple varieties rooted quite readily at the Boyce Thompson Institute following treatment with indolebutyric acid, while others would not respond. Much success has been reported with cuttings of *Taxus*, but Chadwick [14] did not obtain much stimulation with cuttings of most of the coniferous evergreens. Very good results with the broad-leaved evergreens, such as hollies, citrus, and some of the ericaceous plants, have generally been reported. Watkins [15] obtained excellent rooting with cuttings of various warm country plants, many of which offer much difficulty in propagation. The botanical and horticultural journals in many parts of the world now contain accounts of successful propagation of difficult plants with the aid of growth promoting substances.

The Boyce Thompson Institute has tested several hundred species and varieties of plants belonging to

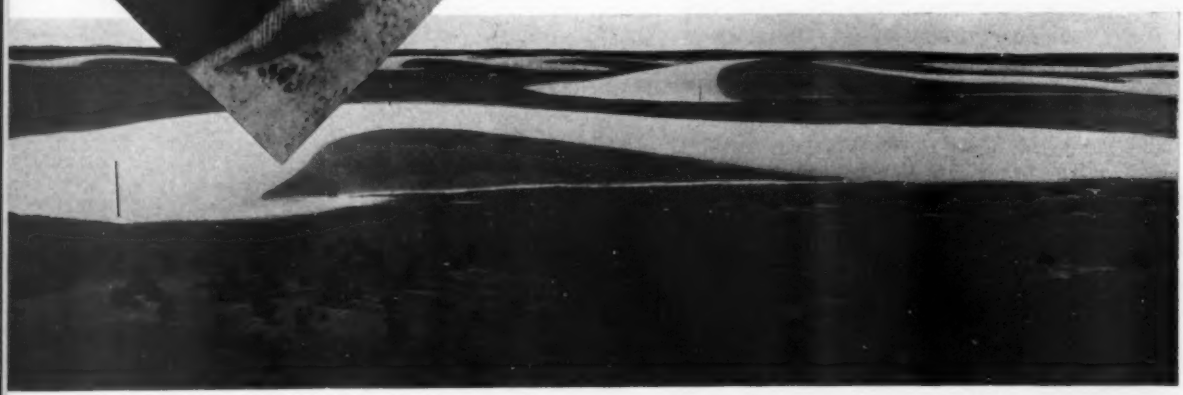
(*Continued on p. 199*)

[14] Chadwick, L. C. Chemicals hasten root growth. American Nurseryman 65: 9–11. 1937.

[15] Watkins, J. V. Experiments with hormodin on tropical and semitropical plants. 1936.

Some of the dunes, as seen from the air.

By June 1936 there had developed 57 small dunes on the field area. The substratum around the dunes was hard and compact.



The RECLAMATION OF A SAND DUNE AREA

by

Charles.J.Whitfield
and
Fred.C.Newport

IN recent years sand dunes have developed as a result of cultivation, grazing, and drought on many sections of land throughout the southern Great Plains where previously no dunes were present. No more striking example of the destructiveness of man-induced wind erosion is known to occur elsewhere. Under virgin conditions topography of the land varied from nearly level to undulating or gently rolling, with a good grass cover and no evidence of dune formation.

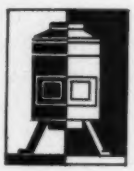
The dunes, as well as the surrounding eroded lands, have approximately no vegetative cover and are valueless in their present conditions; moreover, they are a source of constant menace to surrounding fertile

NOTE.—Mr. Whitfield is in charge, Division of Research, Soil Conservation Service, Dalhart, Tex. Mr. Newport is in charge, Agronomy and Range Management Section, Soil Conservation Service, Amarillo, Tex.

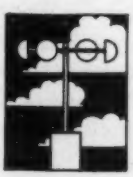
farm lands, pastures, and buildings. The seriousness of the situation can be well appreciated when it is realized that 10 years ago there were no dunes on many of these lands, and that the bulk of the damage has accrued during the past 7 or 8 years. Furthermore, many of these immense piles of sand are now found on areas that were never cultivated, i. e., native prairie sod.

LITTLE or nothing appears to have been done to cope with these severely eroded lands prior to the establishment of the Research Substation at Dalhart, Tex., and inasmuch as they are problems of considerable economic importance it was considered justifiable to initiate studies with the primary objective of determining whether or not such areas could be reclaimed for agricultural purposes. Accordingly, actual work was started in 1936 on three separate fields, while observations were made on numerous others.

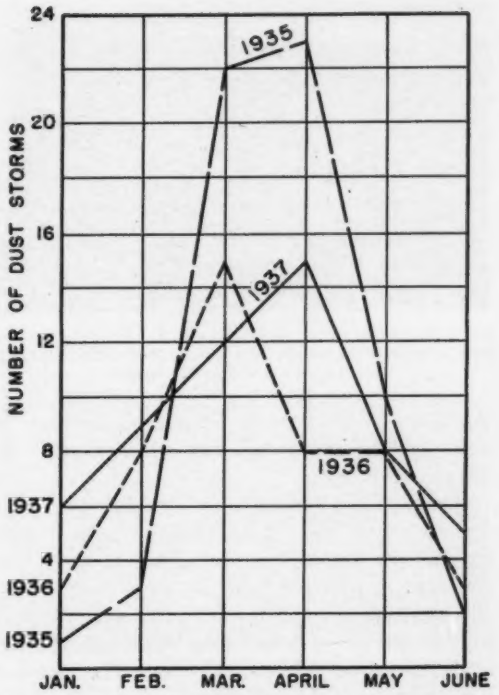
The data herein reported were taken from studies conducted on a single field of 470 acres which is located 8 miles north of Dalhart and consists of the northern portion of section 31, block 1, C. S. S., the eastern part of section 20, all of section 21, block 2, C. S. S. and part of the H. B. Hill survey. The field, which runs in a north-south direction, is over a mile in length and a half mile in width.



Two rain gages were established on the area in September 1936, to measure precipitation, one being placed in the northern half of the field and the other in the center of the southern portion. Data collected from these gages for the 12-month period, September 1936 through August 1937, showed a total precipitation of 11.94 inches. Compared to the 31-year average of 17.84 inches (1906–36) at the United States Dry Land Experiment Station, 3 miles west of Dalhart, this was 5.9 or nearly 6 inches below normal. Moreover, from May 29, when 1.97 inches of rain was recorded, although 16 rains fell, not one of these averaged over 0.5 of an inch until August 31, on which date 1.13 inches was received. These data indicate an abnormal season both as to amount and distribution of rainfall.



Wind velocity data recorded in the vicinity of the area where the field work was conducted showed the average wind movement to be highest during the 5 months—February through June—with the maximum of 12.39 miles per hour occurring in March.



Dust storm record during blowing seasons of 1935, 1936, and 1937.

During these months velocities averaged above 10.5 miles per hour, with February, March, and April being especially high. Winds of sand-moving velocities come from the south, southwest, west, northwest, and northeast; however, indications are that over a period of several months more winds of this kind come from the southwest. Records being kept by the Dalhart demonstration project in cooperation with the Research Division show that it is during this period that the dust storms are of greatest frequency. The total number of dust storms recorded were 61 for 1935, 45 for 1936, and 55 for 1937.

When this field was purchased by Dawson, Fuqua, and Price, in 1930, it was dominated by natural vegetation with blue grama, *Bouteloua gracilis*, and sideoats grama, *B. curtipendula*, as the principal grasses, with sand sage, *Artemisia filifolia*, as the outstanding shrubby plant. The original soils were probably Amarillo fine sandy loam and Amarillo loamy fine sand.

In 1931 the area was cultivated for the first time and planted to row crop. It was planted again to a row crop in 1932 and 1933. Only one crop was harvested

Deep listing of hard land in which the substratum was broken into clods that catch and hold moving sand and do not erode easily.

during this 3-year period. Because of drought and crop failure the land lay idle after 1933 until this work was started in 1936.

When this field was surveyed in 1936, it was found that there were approximately 57 sand dunes located for the most part on the east half of the area. The dunes ranged from 1 to 9 feet in height and averaged 161 feet in length and 113 feet in width. The substratum around and between the dunes was hard and eroded to a depth of 10 to 12 inches. The north and south portions of the field were hummocked and not as badly eroded as the center area.

Studies were conducted on the rate and amount of dune movement on this field site during the fall of 1936. For the 10-week period, August 18 to October 27, 14 dunes were measured, all of which were found to have moved in an easterly direction. Maximum movement recorded was 155 feet. One dune disappeared completely. The average movement from the typical dune ranged between 20 and 30 feet.

The average wind velocity for the 10-week period was 7.45 miles per hour with a maximum of 32 miles per hour.

Work was started in November 1936, on that portion of the field dominated by the hard eroded land and sand dunes. The entire area, including the dunes, was solidly listed (42-inch rows) to a depth of 8 to 10 inches in an east-west direction or crosswise to the prevailing wind direction. A 40-horsepower diesel tractor and a 3-row lister were used. The value of deep listing cannot be overemphasized. Shallow listing may only be conducive to additional blowing, while deep listing, when done in the fall, will not only reduce the blow hazard but prevent erosion, by turning up

A repeat of picture at left, made October 1, 1937. Sudan grass and kafir corn are making a luxurious growth on an area formerly dominated by a hard substratum and sand dunes.

clods of sufficient size to withstand erosion for from 1 to 3 years. In addition, this cloddy surface catches and holds the material which moves off the sand dunes, causing the latter materially to decrease in size, and filling the lister furrows with sand—thus is this badly damaged land being rebuilt. An airplane view made of this field in March 1937, 3 months after the listing was completed, shows clearly how the action of the wind may be used for redistribution of soil materials to rebuild eroded lands. During this period it was estimated that approximately 60 percent of the soil material had been spread back over the field, while the number of dunes decreased from 57 to 29.

Listing was completed in December 1936, and it was unnecessary to relist, except on local spots which were exposed when the sand dunes moved completely away leaving the hard, smooth substratum.

No other mechanical treatment was made on the area until early June 1937, when it was planted to row crop. In order to compare the erosion-resisting qualities of different crops, five species (Sudan grass, kafir corn, black amber cane, millet and broom corn) were listed, while two species (Sudan and hegari) were drilled on the field. The north and south borders were listed as a preventive measure against crop failure and wind erosion, while the center portion was drilled that the two types of cover produced by these methods might be compared.

By harvest time (October) a good cover crop was secured over the entire field, but growth was expecially good on the east half of the area where the sand had redistributed itself to a greater extent. A comparison of the various species planted showed that broomcorn developed a better stand and produced a more vigorous growth under the different soil conditions; Sudan

grass was second in importance, with black amber cane and kafir corn close competitors for third place. From an erosion resistance standpoint, these species also rank in the above order. In other words, broomcorn and Sudan grass appear more resistant to wind action than the other species. However, the forage value of the species would likely be in reverse order, with kafir and Sudan ranking at the top. Probably more Sudan is planted over the country because of its rapid growth, drought resistance, and excellent grazing qualities.

As a result of a soil-conservation reconnaissance survey of the Southern Great Plains wind-erosion area, it was found that "a large proportion of the cultivated and idle lands has already been seriously and irreparably damaged. Pasture lands, which ordinarily are considered well protected by a natural cover of vegetation, are extensively affected by slight erosion and 26.9 percent by serious erosion. Considering lands of all use for the whole area, 9.8 percent has been severely or very severely damaged, which essentially means that it has no further crop-production value." [3]

The studies already initiated, in which wind action, the force primarily responsible for the severe erosion damage, is successfully used to rebuild a severely damaged area to the extent that crops may be produced at a profit after one year's time, present an open question as to the amount of land "irreparably damaged" in this region. Wind erosion differs from water erosion in one primary essential: When soil is carried away by water it is impractical and often impossible to move it back, whereas the action of the wind will often reverse itself and return much of the materials it was instrumental in carrying away. With this as a guiding principal and by the proper use of tillage methods and vegetation, lands which were considered so badly eroded as to be no longer of value from a crop production standpoint may be reclaimed for agricultural use.

Sand moving from the dunes is caught and held in lister rows between dunes.

A repeat of picture above, indicating how badly eroded land has been reclaimed with the development of good row crops after 1 year's time.

[3] Joel, Arthur H., Soil Conservation Reconnaissance Survey of the Southern Great Plains Wind Erosion Area. U. S. D. A. Tech. Bull. No. 556. p. 34. 1937.

Reseeding Grasslands

Three years ago we were of the opinion that a tremendous acreage of grassland, both in semiarid and humid regions, was so seriously damaged by over grazing and neglect that reseeding was necessary. Today, however, after having reviewed the results secured over the 3 years, it is quite apparent that in most localities proper management will bring back a grass cover much more quickly and economically than will plowing and reseeding. Extraordinary results in grassland improvement are secured where weeds are mowed at the proper time and grazing is regulated or restricted for a period of time.

Sixty percent of the native grass in eastern Nebraska has been killed by the drought of the past few years. Undoubtedly, much of this grass would have survived had it been properly managed previous to and during the drought period. Fifty-seven percent of the land in the State is still grassland, although much of it is in very poor condition. When it is considered that 80 percent of the State's agricultural income is from livestock, the importance of grassland is immediately evident.—C. R. E.

"For with the soil washed away, or reduced to sterility, the sea would be the only source of food, and men would become as the fabled icthyopophagi, a rare and scantily fed species, dwelling on the shore and subsisting on what the waters afforded."—Nathaniel Southgate Shaler; Man and the Earth, N. Y., 1906, p. 120.

This snow held in lister furrows and clumps of Russian thistle illustrates advantage of vegetative cover and rough tillage obstruction.

Basin Listing to retain Snow Moisture

by V·H·Florell.

A FIELD experiment was planned in the fall of 1936, to obtain information on basin listing for conservation of moisture from snowfall. The listing was done on cooperators' farms within the Wolsey-Shue Creek demonstration area in South Dakota, from November 18 to December 2, 1936.

The specific objective was to compare the effectiveness of basin listing with that of ordinary listing, and to contrast results from these methods with those obtained on untreated fields previously used for grain and row crops where wind strip cropping is practiced. The plan followed was to basin list, to ordinary list, and to leave untreated about equal parts of each field under experiment. The operations were done on the noncontour because this is the practice followed in wind-strip-cropped fields of undulating topography common in this section. The relative moisture penetration was to be studied at the time of listing and at the end of the winter season.

NOTE.—The author is associate agronomist, Soil Conservation Service, Rapid City, S. Dak.

Materials and Methods

A 3-row lister was used, the lister bottoms being adjusted to cut furrows 42 inches apart. The damming attachment constructed dams at distances of 10 feet. The depth was adjusted to make the listed ridges from 10 to 12 inches high; and the attachment was so arranged that the dams built were from 8 to 10 inches high.

A 1.5-inch soil auger was employed in making the borings for the moisture-penetration observations and an extension auger for some of the deeper borings. All depths of moisture penetration were measured in inches.

In order to obtain a comparison in effectiveness of conservation of moisture run-off, most of the borings were made on slopes of 2 to 4 percent. In the listed portions of the fields most of the borings were made at the bottoms of lister furrows, and in the basin listing usually midway between the dams. For any two treatments under comparison the borings were taken reasonably close together. The types of soil and subsoil were noted for each individual boring. On the

average, four borings were made in each comparison.

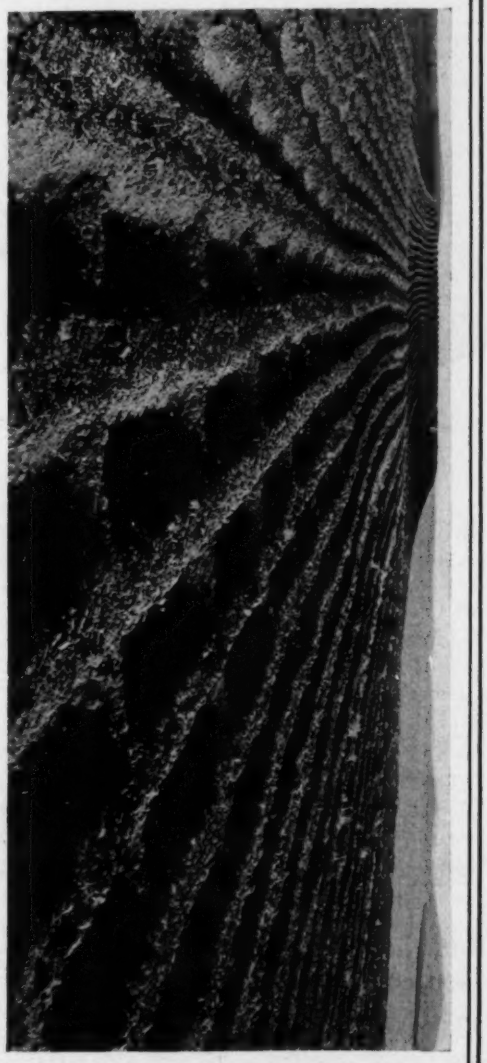
Experimental Data

Due to freezing of the soil it was not practicable to make moisture determinations at the beginning of the experiment. A number of scattered observations on other fields in the demonstration area, however, were made late in the fall which gave a fairly good idea as to the depth of soil moisture at the time of listing. In the Wolsey area the average depth of moisture penetration was approximately 8 to 12 inches in grainfields, and 18 to 20 inches in cornfields. Moisture penetration naturally varied from these figures with different locations and in different soils.

The spring thaw, early in March, was followed by blustery weather for several weeks, and the ground remained frozen until late in April. The borings for the moisture study were made during the period, April 17 to 21. It was found that the lower limits of moisture penetration could be distinguished easily, due to the previous extremely dry condition of the soil. In most cases the limits of penetration were marked by an abrupt change from wet to dry.

The table presented gives a summary of the average moisture penetration in inches for comparable borings. Since the depths of penetration varies according to land use during the season the data are segregated on a land-use basis.

Cornfields were sampled on three farms. As stated previously, the moisture penetration in cornfields in late fall was estimated to average from 18 to 20 inches. In basin-listed land the penetration was 43.8 inches as compared with 30.9 inches on untreated fields, and in the ordinary-listed land on two farms, 37.7 inches as compared with 30.2 inches on the untreated.



Basin listing; dams about 10 feet apart, 6 to 8 inches high. This field is representative of many in the section.

Summary table of results obtained in a comparative soil moisture penetration study of fall basin-listed and ordinary-listed fields on the Wolsey demonstration area, Soil Conservation Service, Huron, S. Dak., April 1937

Number of farms [1]	Predominating soil types	Previous crop (1936)	Treatment	Number of samples	Average moisture penetration (inches)
3	Barnes loam and gradations of fine sandy loam; subsoil, fine sandy and silty clay loam.	Corn	Untreated	9	30.9
			Basin-listed	9	43.8
2		Corn	Untreated	8	30.2
			Ordinary-listed	8	37.7
1	Barnes fine sandy loam and Bearden loamy fine sand; subsoil, mostly sandy loam but some clay loam.	Corn [2]	Untreated	2	92.0+
			Basin-listed	4	85.0+
4	Barnes very fine sandy, and fine sandy loam; subsoil, fine sandy and silty clay loam.	Small grain	Untreated	22	22.9
			Basin-listed	22	24.7
5		Small grain	Untreated	14	26.2
			Ordinary-listed	14	22.8

[1] Not all comparisons were included on all farms.
[2] Data here not included under "Corn" above.

(Continued on page 200)

Rebuilding Pasture Soils

An excellent pasture of white clover may be developed by application of lime and fertilizer.

By Arnold S. Dahl [1]

IN the improvement of old pastures and the establishment of new ones the agronomists of the Service find two of their most difficult problems, and they are well aware that the fundamental cause of the difficulty lies in the low fertility of the soils upon which most pastures are located or planned. In the past, many farmers devoted to pasture only their poorest land, or land that otherwise could not be planted to crops. Other pastures have been established on worn-out croplands, or on soils depleted by years of grazing without replacement of the plant food elements which had been removed in the form of livestock products. Again, many pastures have been injured by overgrazing or improper seasonal grazing, and this misuse has resulted in a poor growth of desirable vegetation and the development of sheet erosion and gullying. This erosion has been accompanied by progressively poorer production and intensified overgrazing, until finally the true pasture plants, which require a high level of fertility, have disappeared to be replaced by weeds such as poverty grass, broom sedge, cinquefoil, broom weed, and others.

IN the humid sections of the country, a pasture vegetation composed mainly of weeds, with much of the ground devoid of cover, is usually indicative of low soil fertility. In such a condition it is necessary, before any success can be obtained from seeding, to raise the level of fertility to a point that will support a vigorous growth of the true pasture-type plants. Usually this can be done by applying fertilizers.

In fertilizing a pasture care should be taken to apply sufficient amounts to produce a high level of fertility in the beginning, rather than to use small amounts annually over a period of years. This allows the better plants to attain sturdy growth within a rela-

[1] Agronomist, Soil Conservation Service, Washington, D. C.

Left—A good turf consisting of grasses and clovers produces abundant feed and provides control against loss of soil and water.

Center—New pasture developed on land retired from cultivation in 1936. Rolling land and natural draws can profitably be used for pastures, with correct fertilization and pasture management.

Right—A poor turf consisting of yarrow, poverty grass, buckthorn, plantain, ragweed, and other weeds. Such a turf provides little feed and poor protection against soil losses.

Left—Contour furrows constructed with machine which does not destroy sod.

Center, below—Contour ridges on level land saves water for use of vetgetation.

Center, above—Contour ridge now completely covered with Bermuda grass. Fertilizer treatments and water conservation pay dividends in increased vegetation.

Right—Overgrazing coupled with low soil fertility induces erosion on hillside pastures. This pasture will continue to lose soil and water until fertilizers are applied and grazing is controlled.

tively short time, and this growth will continue to be vigorous as long as the pasture is properly managed and maintained. Once a pasture is established on a highly fertile soil, the maintenance is easy and production on a high level will continue. On the other hand, when small amounts of fertilizer are applied to depleted and eroded soils there may be little or no response, as the vegetation may be too weak and sparse to prevent erosion or to produce sufficient forage to ustify expenditures for fertilizers. Pastures may thus continue to be poor throughout many years in spite of the usual annual applications.

LIME should be applied to bring the pH value above 6. This may require 1 to 3 tons of limestone per acre. Lime will not only provide a favorable medium for the growth of legumes, but will also encourage the growth of desirable pasture grasses. The addition of lime will tend to make the application of fertilizer more effective and result in better growth of pasture plants.

In certain soils, phosphates, when applied in fertilizers, combine with the chemical constituents in the soil, such as iron and aluminum compounds, and become insoluble and unavailable to the plants. Fixation of this type usually takes place to a greater degree in acid soils of heavy texture. Phosphates may also be combined into relatively insoluble calcium compounds which, however, are less insoluble than the compounds formed in acid soils. As a rule, fixation of phosphates is more complete in heavier soils which are low in organic matter. The addition of organic matter tends to make phosphates of the soil more available—this due to the dissolving action of the acids formed in the decomposition of the organic substances. In a soil well supplied with lime and organic matter, fixation of phosphates ordinarily is not serious. On poor acid soils, however, it is necessary to apply considerable quantities of phosphatic fertilizer to get any immediate response. With the addition of lime, and as organic matter is built up, the fixed phosphates may become available slowly and supply plant needs over a period of years.

The amounts of fertilizer to be applied will vary according to soil type and deficiency of mineral elements. As a rule, agronomists have been too conservative in their fertilizer recommendations. An application of 800 pounds of 16-percent superphosphate per acre once in 4 years is better than 200 pounds per year, or 400 every second year. A heavy application of superphosphate will stimulate legume growth, which in turn will stimulate grasses.

Except in a few specific cases, the use of nitrogen fertilizers is not economical on pastures. Where there is a shortage of feed early in the spring, an application of 100 to 200 pounds of sodium nitrate will give excellent results in encouraging early spring growth so that grazing may begin 2 or 3 weeks earlier. On badly depleted soils which are being seeded to pasture mixtures, applications of nitrogen will result in a quicker and more vigorous plant growth, thus greatly enhancing the possibilities of success from the treatment. Nitrogen fertilizers may also be used to advantage on certain dairy farms where intensive production methods are employed. For the general farmer, however, it is more economical to manage the pastures in such a way that white clover and other legumes will thrive and supply

nitrogen to the grasses. If the mineral plant food content of the soil is adequate, combinations of legumes and grasses are very successful in producing high yields.

Soils in pastures usually are not as deficient in potash as in phosphorus, lime, or nitrogen. In certain soils, however, particularly the lighter soils, and in certain sections of the country, pasture plants respond to applications of potash. In most instances the response to potash is greater when used in addition to nitrogen, phosphate, and lime treatments. Applications of 100 to 200 pounds of muriate of potash are used successfully to satisfy potash deficiency. To determine the need for this fertilizing element, before extending any general recommendations regarding its use, it may be advisable to make a few applications of potash in strips across the fields.

When a farmer has a very large acreage of depleted and eroded lands, the cost of rebuilding fertility of all soils may be more than he can bear. It is advisable, on such a farm, to treat completely as much as the farmer can afford, whether it is 5 acres or 10 acres, and to follow in subsequent years with treatment on additional acres. It is particularly important, in treating pastures to rebuild the fertility of the soil, that a complete treatment be applied on a small acreage rather than an incomplete or inadequate treatment on a larger acreage. A good small pasture will produce returns over a period of years, and the farmer is convinced that it pays to fertilize pastures and is encouraged to treat larger areas. By treating additional small areas year after year, throughout the country, sufficient pasturage can be developed to supply all livestock on all farms without overgrazing. This plan should be definitely provided for in the cooperative agreement, so that at the end of 5 years farmers may have adequate pasturage to meet their needs. Where there is a surplus of land, if not suitable to be placed in crop rotations, the balance can be used for tree production.

The initial application of fertilizer on a pasture should be considered a permanent improvement, not a maintenance measure. The procedure is analogous to the construction of a barn, with initial cost relatively great and with maintenance required as time passes—if a poor barn is built it will always be a poor barn and maintenance costs will be high. Similarly, if a poor pasture is established it will always remain a poor pasture and will depreciate rapidly and require costly maintenance.

On many soils it is not possible to establish stands of sweetclover and alfalfa. Most of these soils are acid and depleted of mineral plant food and organic content. In sections where lespedeza is adapted it grows well on these poor soils. Lespedeza, however, ordinarily should be looked upon as a means to an end rather than as climax vegetation—it is valuable as cover until conditions are such that lime and phosphates may be applied, after which sweetclover can be successfully grown.

Alfalfa cannot be established, even with proper applications of lime and phosphates, until the organic matter content is built up. Here the role of sweetclover is important, as it is often possible to establish alfalfa on land which has been planted to sweetclover over a few years. In sections north of the lespedeza areas, alsike, white clover, and sweetclovers, in mixtures with grasses, may be similarly adapted. Obtaining stands of alfalfa and other high-producing legumes is a matter of building up the fertility of the soil, and should be the ultimate aim of a soil-conservation program in pasture areas.

Maintaining a high level of pasture productivity during summer months is a difficult problem. This is particularly true of pasture containing a large proportion of Kentucky bluegrass which becomes dormant when subjected to periods of high temperatures and drought. In this the condition of the sod is an important factor, since, naturally, the temperature of the soil is much lower under a good sod than under a poor sod. Thus, when the sod is thick and vigorous and has sufficient moisture, air temperature is not so important for the production of forage. On properly fertilized and managed pastures it is moisture that is often the limiting factor and, therefore, the conservation of water becomes the important means of maintaining production during the months of July and August. By holding on the pasture the fall and early summer rains, and those that fall during dry periods in midsummer when the grass is closely grazed and the ground hard, this problem of summer productivity could be mitigated to considerable extent.

Contour furrowing for conservation of water is becoming an important feature of the management of pastures, and the practice has met with considerable success both in the dry regions of the West and the humid regions of the East. In the latter regions, moisture is only one of the limiting factors in the growth of vegetation, lack of soil fertility being most important throughout the greater part of the year. Nor can contour furrows be expected to take the place of fertilizer treatments since, in fact, it is frequently necessary to apply more fertilizer to the furrows and ridges than to the balance of the pasture—

this because of the poorer soil that is exposed in construction.

A great many furrows have failed to show any improvement, and some have actually caused decreased growth, because they were not sufficiently fertilized. Without doubt it is important that contour furrows be fertilized heavily if prompt results are to be realized.

In the West, where gentle slopes prevail, contour ridges which back the water over a large area when spaced relatively far apart, have proved very successful. In the East, where the land is more sloping, such ridges are less satisfactory. Many of these furrows are too deep and the ridges too high and too large, the greatest amount of improvement in the turf occurring in the bottoms of the shallow furrows and not extending, except in a few cases, very far from the limits of the furrows, thus leaving the greater part of the sod in the interval between furrows unimproved. It is apparent, therefore, that wide shallow furrows placed to adjoin one another will provide the greatest conservation and the best distribution of the water. In fact, when a few of these furrows were observed the broad band of vigorous vegetation was very marked.

Broad, flat-bottomed contour furrows can be built by one round of a disk harrow, leaving a broad shallow depression with sloping sides. A similar furrow can also be constructed by throwing two furrow slices in opposite directions, one up the slope and the other down the slope, and leaving a 6- to 10-inch balk in the center of the dead furrows. A harrow is then run over this balk to spread topsoil in the bottom of the furrows and on the sides. These furrows may be close enough together to allow backfurrows and dead furrows to alternate on the contour across the field. Such construction leaves a concave type of surface on the field, rather than the convex type usually seen where contour furrows have been built. As for the area improved through conservation of water by means of this type of construction, it will vary in size according to the amount of surface in the furrows and ridges—the greater the area in the furrows and the more diminished the area in the ridges, the wider the distribution of water for utilization by the pasture plants. The construction of furrows as outlined above replaces plowing in the preparation of a seedbed, thus necessitating little additional cost in establishing new pastures and in improving pastures where the sod is so poor that plowing is advisable.

If a fairly good sod is present, it is not usually advisable to plow the pasture; instead, in such a field, the furrows should be constructed with other implements. A chisel-type subsoil plow, run on the contour at a depth of 24 to 30 inches at intervals of 3 to 4 feet has been used to form a series of small ridges with wide shallow flat-bottom depressions between them, and this method appears to be very satisfactory in conserving water and in promoting growth on some soil types. It is not known, however, how long such ridges will retain an effective height. A new type of contour furrowing machine, lately developed in Iowa, constructs furrows without injuring any of the sod. Such machines are needed in all projects where contour furrowing is required on pastures with fair sod already present.

A good sod in a permanent pasture cannot be developed in a single year, chiefly because most of the important plants are perennial and require time for development in size and number. The first year's growth will consist mainly of annuals and short-lived perennials, and these will gradually be replaced by the permanent vegetation. Many newly seeded pastures which apparently are making very poor growth will develop in time to a vigorous sod. Likewise, it takes time for lime and fertilizer treatments to become fully effective. The time required to develop a good sod is considerably shortened, however, if contour furrows are constructed and if a liberal fertilizer treatment, with manure or mulch, is applied.

SYNTHETIC GROWTH SUBSTANCES

(*Continued from p. 189*)

about 85 different genera, and almost all of these have responded in some degree to the treatment. The few plants which could not be rooted may possibly be handled successfully later when more is learned about their individual requirements. The value of the treatment for rooting the most difficult plant subjects is not well enough established to justify unbounded enthusiasm. The shortening of the time of rooting of cuttings and the increasing of the number of roots produced are sometimes the only noticeable benefits. However, if so much progress has been made in the past few years, may we not hope for even more in the future?

A masterly summary of the theoretical and practical aspects of plant hormones has just been written by Went and Thimann.[16] These authors have done much to systematize and correlate the scattered mass of facts about plant hormones. While the phytohormone is

(*Continued on p. 202*)

[16] Went, F. W., and Thimann, K. V. Phytohormones. New York. 1937.

BASIN LISTING

(*Continued from p. 195*)

Data obtained from one cornfield were not included in the above averages. The soil here consisted chiefly of Bearden loamy fine sand and Barnes fine sandy loam which are underlain by a sandy loam subsoil and some clay loam subsoil. The subsoil in a number of the borings was mostly sand. These soils absorb water readily and Bearden particularly is very susceptible to wind erosion (blowing). Both on the untreated and on the basin-listed parts of this field an abundance of moisture was present to a depth of more than 7 feet (92+ and 85+ inches respectively). No dry soil was found in any of the borings. On an adjoining field sown to grain in 1936, but overgrown with Russian thistles, the average depth of moisture penetration was 25.5 inches.

The total precipitation from December 1 to April 21 was 5.01 inches of which 4 inches were from snow. The precipitation after April 1 was partly rain and partly snow. Snow at this time was very wet and heavy. From December 1 to April 1, 40 inches of snow was reported by the United States Weather Bureau at Huron, S. Dak., with a water content of 4 inches. The precipitation and snow at Wolsey was virtually equal to that at Huron.

All cornfields under treatment had been practically denuded by grasshoppers. Where grain had been sown in 1936, a more or less dense growth of Russian thistles occurred. On the average, the weed growth was from 3 to 6 inches tall and usually with only a moderately dense stand of plants.

Measurements of moisture penetration on grain land were taken on five farms. The average penetration on the untreated land for all samples (36) was 23.9 inches, on basin-listed land 24.7, and on the ordinary-listed land 22.8 inches. Very little additional conservation of moisture was effected by the use of basin listing above that of ordinary listing, or above that on untreated land. Here very little soil moisture increase was obtained in the basin listing, and negative results were obtained in the ordinary listing.

In comparing these fields it should be mentioned that the average depth of moisture penetration in the lister ridges was somewhat greater than that at the bottom of the furrow, and that an addition of about 2 or 4 inches might be made to the figures given for both basin listing and ordinary listing. The limits of moisture penetrations in a number of adjacent furrow and ridge determinations, however, averaged several inches lower below the furrow than below the ridge.

Borings were taken also on two fallow fields with the adjoining untreated fields for comparison in each instance (four samples for each comparison). These fields had been sown to grain in the spring of 1936. The average depth of moisture penetration for the fallowed fields (plowed in June) was 18 inches, and for the adjoining fields, 25.3 inches. This shows a greater amount of moisture on the untreated land than on the fallowed land. Apparently this is an unusual condition partly due to limited summer rainfall.

The total average rainfall from July 1, 1936 to April 20, 1937 (data from two cooperative weather observers near sampled fields) was 9.12 inches which was but 4.55 inches above that received from December 1 to April 20. Since rainfall was limited, very little moisture was stored by fallowing during summer. Some run-off also may have occurred from the moderately heavy August rains.

Throughout most of the winter the fallow as well as the denuded cornfields were free from snow. The adjoining fields covered with a moderately dense, though short growth of thistles, held much of the snow where it fell, the result being that the untreated land showed considerably more moisture penetration than the fallowed land.

From the data presented in the table it may be concluded that a significant amount of moisture was conserved by use of the basin lister on denuded cornland. An increased soil-moisture penetration of 12.9 inches above that of the untreated was shown for the basin listing, and 7.5 inches for the ordinary listing, or an increase of 40.4 and 24.8 percent respectively. These results indicate that a significant amount of snow moisture may be conserved by using a lister on bare land in the winter. The amount of moisture saved depends largely on weather conditions. In a cold winter when the ground is frozen to a considerable depth with much snow, followed by a rapid spring thaw, it is likely that most of the snow water would be lost as run-off on both untreated and ordinary-listed land having appreciable slope. Basin listing in such a case would do much good in trapping the moisture. During the past season the spring thaw occurred gradually, permitting snow moisture to penetrate the soil to a greater extent than it would have done under conditions indicated above.

Very little increase in moisture penetration was observed between the basin listed and untreated portions of fields on grain land, and negative results were obtained with the ordinary lister on grain land. The unlisted portions were well covered with Russian thistles. The thistles held considerable snow which on the average was estimated to be somewhat greater than that held by the lister furrows. The results ob-

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BOOK REVIEWS AND ABSTRACTS

By Phoebe O'Neall Faris

SOLON ROBINSON, PIONEER AND AGRICULTURIST, Volume II, 1846–51. Edited by Herbert Anthony Kellar. Indianapolis. 1936–37

We welcome volume 2 of the writings and letters of this pioneer conservationist who more than a century ago warned farmers about taking the "skin" off the land and suggested rather ironically that if the people could not be induced to preserve and cultivate the natural forest it was the duty of the Government to plant groves of timber on the vast tracts of the western prairie land.

Upon viewing Stone Mountain, in 1851, Solon Robinson described the phenomenon as "an immense mass of naked granite . . . a landmark that will endure forever" and added half regretfully "If it had been a lime rock, it would have been more valuable to the agriculturist." And, far northward from the salubrious climate of Georgia, in Kingston, Ontario, witnessing the march of somewhere near a thousand of "Her Majesty's Rifles" through the street, he remarked that the soldiers were all "stout, athletic young men, and I could not help thinking what an amount of human food might be produced by the well-directed labor of all these eaters of the bread of idleness." Such a man was Solon Robinson throughout his years—living, hoping, and planning for agricultural improvement. For cities he had little use. Railroads might prove of value—for hauling lime to worn-out acres and farm produce to markets. The manufacturer had his place in the sun as the producer of equipment for deep plowing, subsoiling. Quartz rock was for garden walk borders, to beautify the farm-home surroundings.

In these middle years of his life he traveled the country over searching out the "improving agriculturist" that he might write descriptions of better farm methods, contrast "slack" and "snug" farmers and their establishments.

His enthusiasm knew no bounds when in his travels in the Carolinas he came upon a planter who would not allow his great plantations to be "utterly ruined" by the methods of overseers, but who took the situation in his own hands and "determined to apply the knowledge he had gained from reading and traveling, and devote all the energies of his strong mind to an effort to change that old, ruinous system which has nearly destroyed and depopulated some sections of the South." Continuing eagerly, words tumble over words as Solon Robinson describes the amazing innovations on the great plantations: "In the first place, cotton is utterly discarded from the premises, and clover—yes; rich, luxuriant red clover, by the hundred and thousand acres—has been made to grow where nothing but broomsedge and old field pine grew before."

Rotation cultivation on these plantations excited his admiration and with ardor he outlined the system for readers of the American Agriculturist: ". . . commence with a field at rest and plow 10 inches deep in April or May and sow cowpeas broadcast and harrow in; or break up . . . in the fall or winter, turning under all the manure that can be given. In the spring plant corn and, at the last working of the corn, sow peas broadcast; cut off the corn in September, plow under the peas, and give a top dressing of lime . . . and then sow and harrow in 5 to 8 pecks of wheat per acre. In February or March, following, sow 4 quarts of clover seed per acre. Harvest the wheat in June, and sow 1 bushel of plaster [white melilot?] per acre, and pasture lightly during the summer . . . . Manure is used, either upon corn or wheat ground, on such parts as require it most. But after the land is brought to that state, by means of the valuable system of plowing, manure, and lime, that it will produce a good crop of clover, Mr. B. [the planter] is sure of a good crop of wheat or corn, whenever required." Surely this rotation system, practiced 100 years ago on these North Carolina estates, is worthy of note today. And who wouldn't like to know what has happened to those thousands of acres through the century, and their condition today.

As a contribution to Americana the Solon Robinson volumes are important. For example, on the 11th of February, 1849, Robinson wrote from Plaquemine, La., for the Daily Cincinnati Gazette "Messrs. Editors: I am shut up—cabin'd—crib'd—confined—i. e. I am *located* just here while it may please heaven to grant a cessation to this outflowing, down tumbling, 2 days' shower. And unless you 'up-country folks' soon cease to send down your floods, wo be to this devoted land. What a satisfaction it would be now if we were all assured that we were born to be hung, for then we should feel safe; whereas the drowning prospect is just now much the strongest." There follows a vivid description of a lower Mississippi flood—steadily rising waters, flooded crops, "cholera times," the broken levee and towns and plantations under water, an icy wind from out the north and steamboats coated with ice. And then, the excitement of the flood past, in his zeal for soil improvement, a planter is commended for using bagasse from his sugar mill as manure, while in the same breath, so to speak, another planter who burns bagasse is "lashed" for being "still disposed to practice this method of destroying a valuable article for manure."

Robinson's account of the Great Poultry Show at Boston in November 1850 is a gem of humorous writing, while his Lecture on the Early History of Lake County, Ind., is probably one of the most vivid pictures of prairie agricultural pioneering that has come down to us from the covered-wagon era.

ECOLOGICAL ANIMAL GEOGRAPHY. By Richard Hesse, W. C. Allee, and Karl P. Schmidt. New York and London. 1937.

This is an authorized, rewritten edition in English, based on *Tiergeographie auf oekologischer Grundlage* by Professor Hesse of the University of Berlin. The volume makes accessible to students in America a great deal of European literature on zoögeography and has the added advantage of presenting ecological problems on a world-wide basis. The last chapter in particular, which discusses the effect of the rapid and recent advances of civilization upon primeval communities of plants and animals, is written from the American point of view and in the light of American experiences. The change in environmental conditions through deforestation, draining of swamps and marshes, irrigation, crop cultivation, etc., is pointed out in some detail to show the effect of man and his activities on animal communities.

Throughout the book emphasis is upon distribution of animal communities rather than vegetation or elements of the nonliving environment. In the main, the investigations are directly concerned with the adaptation of animals to their environment and the influence of environment upon the animals. The first part of the volume consists of studies of the ecological foundations of zoögeography including conditions of existence, environmental selection

BOOK REVIEWS AND ABSTRACTS
Continued

and classification, barriers and means of dispersal, geographic isolation, historical accounts of the faunal regions of the earth, and extent of range. The remaining three parts treat directly and separately the composition of animal communities in marine waters, in inland waters, and on land.

Chapters having special interest for the conservationist are those dealing with animal communities in standing waters and other inland waters, forest communities, dry, open land habitats, swamp and shore dwellers, and alpine zones. The bibliography is unusually extensive and valuable to the student of ecological animal geography.

C. C. C. FORESTRY. Compiled by H. R. Kylie, G. H. Hieronymus, and A. G. Hall. United States Government Printing Office, Washington, D. C. 1937.

This is a very interesting book, well set up in the popular manner. It is recommended by the Woodland Management Section as valuable not only for C. C. C. boys but for all members of the Service. We are told also by the foresters that it has the great advantage of having been compiled by men who have made no technical errors—a feature not always found in popular manuals. The volume is richly illustrated throughout with photographs, charts, and marginal pen-and-ink sketches. The sketches are particularly pleasing as they are well designed and arranged to interest and instruct readers who are not equipped with the technical background necessary to the intelligent study of most books on forestry.

The text is divided into 14 chapters and presents in a simple manner the approved practices for forest conservation and forest utilization. The appendix contains a cross reference guide to be used with C. C. C. Vocational Series No. 8, a list of 100 important trees in the United States and their ranges, and a glossary of forestry terms. It is the opinion of the reviewer that this book would be very valuable to farmers owning woodlots as well as to the C. C. C. enrollees and conservationists.

620 MILES OF CONTOUR FURROWS

(Continued from p. 177)

second, to speed up the stabilization of the entire watershed; and third, to form windbreaks to aid in holding snow on the area.

A severe test of the furrows came within a year after construction was started. Torrential rains fell on the Pocatello area, amounting to more than 2 inches in less than a 24-hour period. There was no flood from the portion of the watershed that had been treated. On an adjacent untreated watershed run-off was heavy, carrying debris into the city and washing out a short section of street to a depth of 8 feet. Moisture penetration 3 days after the rain was 7 to 10 inches on the areas between furrows, and 16 to 24 inches in the furrows.

SYNTHETIC GROWTH SUBSTANCES

(Continued from p. 199)

but one of the various essential factors in plant growth, the rapid development of this new field is revolutionizing plant physiology. For the first time logical and demonstrable explanations of some hitherto puzzling types of plant behavior can be made. That these phytohormones now happen to have an immediate practical application is a fortunate accident. The past history of science has shown that knowledge which is of very little value at the time of its discovery may have valuable practical applications later.

BASIN LISTING

(Continued from p. 200)

tained emphasize the important role played by vegetative cover in conserving snow moisture. About 8 percent increase in moisture penetration resulted from basin listing, as compared with the untreated land.

It should be repeated here that the greater amount of penetration in cornland over that in grain land was due to a difference in moisture reserve in the fall. Last summer and fall the soil moisture from rain in thistle fields was quickly depleted, but in the cornfields the moisture reserve increased appreciably toward the end of the season.

The results obtained indicate that considerable moisture from snow may be conserved by fall listing on land devoid of vegetative cover. On land having vegetative cover very little additional moisture can be saved by listing, providing slopes are not excessive and the soil at the proper time is in condition for absorption. Basin listing is more effective in the conservation of snow moisture than ordinary listing.

Contour Listing of Corn

Some of our projects in the Corn Belt have introduced listers, and many of the farmers have listed their corn on the contour. The results secured are surprising, as on many farms much better yields are obtained from the listed corn than from adjoining checkrow plantings. Such objections as crooked rows, point rows, difficulty in controlling weeds, and others raised by the farmers, seem to disappear when contour listing is given a trial.

TENTATIVELY SCHEDULED

February—Special Research Issue.
March—Special S. C. S.-C. C. C. Issue.

U. S. GOVERNMENT PRINTING OFFICE: 1938